AN

ACCOUNT

OF THE

MOST APPROVED MODE

OF

DRAINING LAND, &c.



44 b 12

AN

ACCOUNT

OF THE

MOST APPROVED MODE

OF

DRAINING LAND;

ACCORDING TO THE SYSTEM PRACTISED BY

Mr. JOSEPH ELKINGTON,

LATE OF PRINCETHORP, IN THE COUNTY OF WARWICK:

WITH

AN APPENDIX,

CONTAINING

HINTS FOR THE FARTHER IMPROVEMENT OF BOGS AND OTHER MARSHY GROUND, AFTER DRAINING;

TOGETHER WITH

OBSERVATIONS ON HOLLOW AND SURFACE DRAINING IN GENERAL.

THE WHOLE ILLUSTRATED BY EXPLANATORY ENGRAVINGS.

DRAWN UP FOR CONSIDERATION OF THE

BOARD OF AGRICULTURE AND INTERNAL IMPROVEMENT,

BY

JOHN JOHNSTONE,

LAND-SURVEYOR.

" *Humidiorem agrum fossis concidi atque siccari,*
" *Utilissimum est.*"———— PLIN. NAT. HIST.

EDINBURGH:

PRINTED BY MUNDELL AND SON, AND SOLD BY G. NICOL, PALL-MALL, LONDON, BOOKSELLER TO HIS MAJESTY, AND TO THE BOARD OF AGRICULTURE; AND BY MESSRS. ROBINSONS, PATER-NOSTER-ROW; T. SEWEL, CORNHILL; CADELL AND DAVIES, STRAND; W. CREECH, EDINBURGH; AND T. ARCHER, DUBLIN.

1797.

AN

ACCOUNT

OF THE

MOST APPROVED MODE

OF

DRAINING LAND:

ACCORDING TO THE SYSTEM PRACTISED BY

MR. JOSEPH ELKINGTON,

LATE OF TWINCKTHORN, IN THE COUNTY OF WARWICK:

WITH

AN APPENDIX,

CONTAINING

HINTS FOR THE FURTHER IMPROVEMENT OF BOGS AND OTHER MARSHY GROUND, AFTER DRAINING:

OBSERVATIONS ON HOLLOW DRAINING IN GENERAL.

THE WHOLE DRAWN UP FOR CONSIDERATION OF THE

BOARD OF AGRICULTURE AND INTERNAL IMPROVEMENT,

BY

JOHN JOHNSTONE,

LANCASTER-SQUARE.

Entered in Stationers Hall.

G.R. III.
BRITISH MUSEUM

PRINTED BY MUNDELL AND SON, AND SOLD BY C. NICOL, PALL-MALL, LONDON,
BOOKSELLER TO HIS MAJESTY, AND TO THE BOARD OF AGRICULTURE; AND
BY MESSRS. ROBINSONS, PATER-NOSTER-ROW; T. SEWELL, CORNHILL;
CADELL AND DAVIES, STRAND; W. CREECH, EDINBURGH;
AND T. ARCHER, DUBLIN.

1797.

ADVERTISEMENT.

THE Board of Agriculture had hardly been eſtabliſhed, before it received intelligence from various parts of England, of the ſingular, and almoſt incredible ſucceſs, with which Mr. Joſeph Elkington, a Warwickſhire farmer, practiſed the Art of Draining Land; the publication or diſcovery of which, was repreſented to be one of the greateſt means of promoting the improvement of this Country that could poſſibly be ſuggeſted. It is unneceſſary to trace the various ſteps taken by the Board for attaining ſo important an object. It may be ſufficient to mention, that in conſequence of a motion made by its Preſident, on the 10th of June 1795, the Houſe of Commons voted an addreſs, "That his Majeſty

" would be graciouſly pleaſed to give directions
" for iſſuing to Mr. Joſeph Elkington, as an in-
" ducement to diſcover his Mode of Draining, ſuch
" ſum as his Majeſty in his wiſdom ſhall think pro-
" per, not exceeding the ſum of 1000l. Sterling,
" and to aſſure his Majeſty that this Houſe will
" make good the ſame to his Majeſty."

Mr. Elkington's health being extremely precarious, there was a riſk that the public might loſe the benefit of the knowledge he had acquired, by the experience of above 30 years, in a ſpecies of Improvement, which in theſe kingdoms ought to be conſidered as the baſis of every other. To prevent ſo unfortunate a circumſtance, the Board reſolved to ſend Mr. John Johnſtone, to viſit, in company with Mr. Elkington, the principal Drainages he was executing, and to take Drawings thereof. It is to be hoped that the following Report, the reſult of that journey, with the annexed Views and Sections, will

furniſh the reader with very ſatisfactory information upon the ſubject of this art, and, indeed, that, together with the Appendix, it will ſufficiently explain all the various Modes of Draining Land, whether practiſed by Mr. Elkington or others.

London, May 1797.

PREFACE.

THE writer, having, by appointment of the Board of Agriculture, and of the Highland Society of Scotland, accompanied Mr. Elkington, on a ſurvey through thoſe counties of England, where he was executing the moſt remarkable drainages at that time (in ſummer 1796), for the purpoſe of acquiring a knowledge of his art; and having thus had an opportunity of ſeeing the operation carried on in all its ſtages, he hopes the following pages, will be found to contain the fulleſt and moſt correct narrative of that uſeful diſcovery, hitherto laid before the public:——A diſcovery, by which many thouſand acres of the ſouthern part of this iſland have been already ſo much improved. When the writer has ventured to propoſe any thing new, or that does not come within the bounds of Mr. Elkington's practice, he has done ſo, not with a view of recommending *HIS OWN*, but from a deſire of giving hints that may be uſeful to others.

THE obſervations he has ventured to ſuggeſt, with regard to the importance of the object he is deſcribing, and the *REAL* advantages to be derived from Mr. Elkington's mode of draining, he has endeavoured to eſtabliſh, by authentic quotations

from the Agricultural Reports of thoſe counties in England, where theſe advantages are taken notice of; and from other ſatisfactory ſources of information.

It cannot be expected, that he is to enter into a learned diſquiſition on the nature of ſprings, a phyſical inquiry into the cauſe and formation of bogs, or into a chemical examination of the qualities of ſoil:——Theſe are reſearches that come not within the limits of his knowledge, although in ſome degree connected with the ſubject. He will content himſelf with briefly ſtating facts, ſo far as to explain the principles of the art, and will endeavour to convey its meaning in the beſt language he can, ſo far as the nature of the ſubject will admit. Where he has uſed provincial words, which are almoſt unavoidable in a georgical treatiſe of this kind, he has done ſo, becauſe they are the terms of expreſſion commonly applied; but he has alſo added ſuch explanation, as will render their meaning generally underſtood.

Being aware, that, without the help of explanatory ſketches, it would have been impoſſible to convey a juſt idea of the nature and principles upon which the ſyſtem is founded; he has therefore given ſuch Plans of the various ſituations, and Sections repreſenting the inclination of thoſe internal ſtrata, that produce ſprings and wetneſs in ground, as he hopes will be uſeful in facilitating the acquirement of that knowledge. The origin of

this diſcovery he has thought proper to explain, which, although immaterial in itſelf, may ſerve as a proof of the circumſtances that firſt led Mr. Elkington to a knowledge of the art.

To the drainage of bogs and other wet ground cauſed by ſprings, he has confined the ſubject of this Report, more than to that of ſoils that are injured only by rain water ſtagnating on the ſurface; the former being a branch of the ſyſtem that has hitherto been leſs known or attended to, and as the latter is a part of it more generally underſtood, and not ſo much the object of Mr. Elkington's practice.

The mode, however, of draining ſome ſoils, the wetneſs of which does not proceed from continual ſprings, and where the auger is ſeldom applied, he has endeavoured to point out in a manner whereby it may be accompliſhed by means of much leſs cutting and expence than what has formerly been practiſed. In the Appendix he has offered hints which, he hopes, may be uſeful in directing the further improvement of bogs, &c. after being drained; and alſo obſervations on the different modes of hollow and ſurface draining in general, as more eſpecially practiſed in the eaſtern counties of England.

To the Board of Agriculture, &c. and to the Public, this Treatiſe is humbly offered, with a view to facilitate the acquiſition of this uſeful art; and if, through its means, a deſire to

profecute the improvement it recommends ſhould be excited, the writer will feel a ſatisfaction, by having in ſome degree contributed to eſtabliſh that important object; hoping, that by the influence of that Honourable Board and of the Society, under whoſe patronage he attended Mr. Elkington, the knowledge of it will be ſo much extended, as to render the practice of it general, in every ſituation where it may be applied with advantage.

When it comes into the hands of ſome of thoſe intelligent Gentlemen, who have ſeen and are acquainted with the nature and method of Mr. Elkington's ſyſtem, the writer hopes they will paſs over any imperfections that this account may contain, and will not heſitate to correct its errors, or to ſupply its defects.

CONTENTS.

Page.

INTRODUCTION, ... 1

CHAP. I. An account of the Origin of the Diſcovery, and Means that firſt led Mr. Elkington to a Knowledge of the Art, ... 5

CHAP. II. On the Principles of Mr. Elkington's Mode of Draining, ... 13

CHAP. III. Drainage of Bogs, and other Wet Ground, cauſed by Springs, . . 19

CHAP. IV. Drainage of Hills and Sheep Paſtures, with Obſervations on the Means of procuring and raiſing Water for Wells, &c. 43

CHAP. V. Drainage of Bogs, and other Wet Ground, by perforating through a Retentive to a Porous Subſtratum, ... 51

CHAP. VI. Drainage of Soils compoſed of alternate Beds of Clay and Sand, . . 65

CHAP. VII. Drainage of Soils Porous above and Retentive below, &c. . . . 72

CHAP. VIII. Drainage of Mines, Quarries, Marl Pits, &c. 77

CHAP. IX. Obſervations on the Uſe of the Spirit Level, with Directions for uſing it in the marking out of Drains, ... 89

CHAP. X. Deſcription of the Auger, and Manner of uſing it, &c. 95

CHAP. XI. Extracts from ſome of the Agricultural Reports of thoſe Counties in England where Mr. Elkington has executed the moſt remarkable Drainages, &c. tending to authenticate the Advantages derived from his Practice, ... 101

APPENDIX.

PART I.

Hints for the Improvement of Bogs, &c. after being drained, ... 117

PART II.

Obſervations on Hollow and Surface Draining in general.

Page.

Introduction, ... 131

Sect. I. Antiquity of the Practice of Hollow Draining, ... 132

Sect. II. When firſt uſed in England, ... 134

Sect. III. Nature of the Moiſture or Wetneſs againſt which they are chiefly uſed, 136

Sect. IV. Of the Soils in which they act, and of thoſe on which they have been found to fail, ... 137

Sect. V. By what Rules their Direction is marked, ... 139

Sect. VI. Seaſon for executing the Work, ... 142

Sect. VII. Manner in which Drains are partly opened by the Plough, . . 144

Sect. VIII. Depth and Width, ... 146

Sect. IX. Tools employed, ... 148

Sect. X. Of digging Hollow Drains, ... 149

Sect. XI. Opening Drains by the Plough only, ... 150

Sect. XII. Materials with which they are filled, ... 153

Sect. XIII. Mode of Filling, ... 161

Sect. XIV. Of the Expence, ... 162

SECT. XV. Of Sod or Pipe Drains, ... 165

SECT. XVI. Duration of Covered Drains, ... 168

SECT. XVII. Drainage of ſtiff and retentive Soils, by open Cuts, and the proper Formation of Ridge and Furrow, ... 169

SECT. XVIII. Mode of Draining Clay Soils practiſed by Sir Henry Fletcher, Baronet, a Member of the Board of Agriculture, ... 176

SECT. XIX. Of the Benefit derived from the Practice of Draining in general, 179

CONCLUSION, ... 183

Conclusion 193
Sect. XIX. Of the Bounds which limit the Faculties of Demons in General 177
Sect. XVIII. Some of Demons Power in Matter explained, &c. 170
Sect. XVII. Of the Production of Light and Colours 163
Sect. XVI. Of Soul or Type Demon 158
Sect. XV. Division of Created Demons 150
Sect. XIV. Demonology and Revelation agree, of what Use and the Pro-
per Formation of Angels and Archons 143
Sect. XIII. Some of Demons Power in Matter explained, &c. 136
Sect. XII. Of the Bounds which limit the Faculties of Demons in General 131
Sect. XI. Of Soul or Type Demon 125
Conclusion 121

INTRODUCTION.

Of all the arts that have excited the attention, or called forth the exertions of mankind, none has been diſcovered ſo valuable or ſo generally uſeful as *AGRICULTURE*, not only by rewarding the ſkill and induſtry of the individual, but by exalting the proſperity of a nation.

It is undoubtedly the moſt ancient, and the foundation on which all other arts depend; a foundation every day becoming ſtronger and more reſpectable, by acquiring ſupport and encouragement from the firſt characters in this kingdom. Having now attained that degree of reſpectability which its nature and utility as a great national object deſerves, it cannot fail of exciting a very general attention to the practice of it; a practice by which the permanent intereſts of the kingdom may be ſo much advanced. Agricultural purſuits are, of all others, the moſt conducive to health and vigour. The ſtudy or theory of it enlarges the intellectual, and its practice employs in uſeful exerciſe the active powers of man. By much the greateſt part of this iſland, both with regard to ſoil and climate, is very

favourable to agriculture, and capable of much improvement, the means of which are almoſt every where at hand. It is not the intention of this Treatiſe to ſhow what are the general improvements connected with agriculture, but to explain and deſcribe that branch of it alone which may not only be reckoned the moſt important, but one upon the practice of which moſt of the others, in certain ſituations, depend. It is ſurpriſing that ſo few attempts have been made to reclaim and improve ſome of the many extenſive tracts of *WET BOGGY LAND* that are every where to be met with in this country; which, in the language of a late writer *, are "at preſent a reproach to the age, a diſgrace to the country, and a nuiſance to the occupiers †." In point of local advantages, land of this deſcription has a preference to every other kind of waſte ground, by being more productive when improved, and often lying in ſituations more ſheltered and acceſſible to improvement, than many parts of barren land, which, although dry, are in other reſpects leſs

---

* MR. BOSWELL on Water Meadows.

† IN an addreſs by the Preſident to the Board of Agriculture, on the cultivation and improvement of the waſte lands of Great Britain, printed in December 1795, he ſays, "A conſiderable proportion of the waſtes of Great Britain conſiſts of lands of a wet and boggy nature, which it has been yet ſuppoſed was the moſt difficult to improve and cultivate. Fortunately, however, diſcoveries have been made in the art of draining ſuch bogs, by Mr. Joſeph Elkington, a farmer of the county of Warwick, as renders the improvement of ſwampy land a matter of much leſs difficulty or expence than formerly."

favourable to cultivation. Draining is the firſt ſtep towards the improvement of theſe, as well as of every other ſpecies of wet land. It is in every reſpect the moſt eſſential method by which their improvement or cultivation can be accompliſhed; and, when executed with judgment, the advantages derived from it are not only immediate, but ſure and permanent. If land be in tillage, and remain wet, every manure that can be applied to it loſes its effect, and fails to produce ſo abundant a crop as a much leſs quantity would yield when the land is dry. If in paſture, the graſs it produces is of a coarſe unhealthy nature, fit neither for feeding of ſtock, nor for being converted into hay. In ſheep walks, the bad effects of wetneſs are often ſeverely felt. The rot, that deſtructive malady among ſheep, chiefly proceeds from the nature of the herbage which too much noxious moiſture produces; and as it is a diſeaſe hitherto deemed incurable, it can only be *PREVENTED* by means of draining.

THE effects of draining, on the climate, are alſo conſiderable. In hot weather, the exhalations that ariſe from large tracts of moſs and marſhy ground, muſt increaſe the humidity of the climate, and render it unſalubrious to the inhabitants, as well as injurious both to animal and vegetable life; hence, in ſuch ſituations, animals are unhealthy, and every kind of grain is longer in coming to maturity, its harveſt precarious, and the quality of its produce inferior, occaſioned by the dampneſs of the ſoil, and impurity of the atmoſphere.

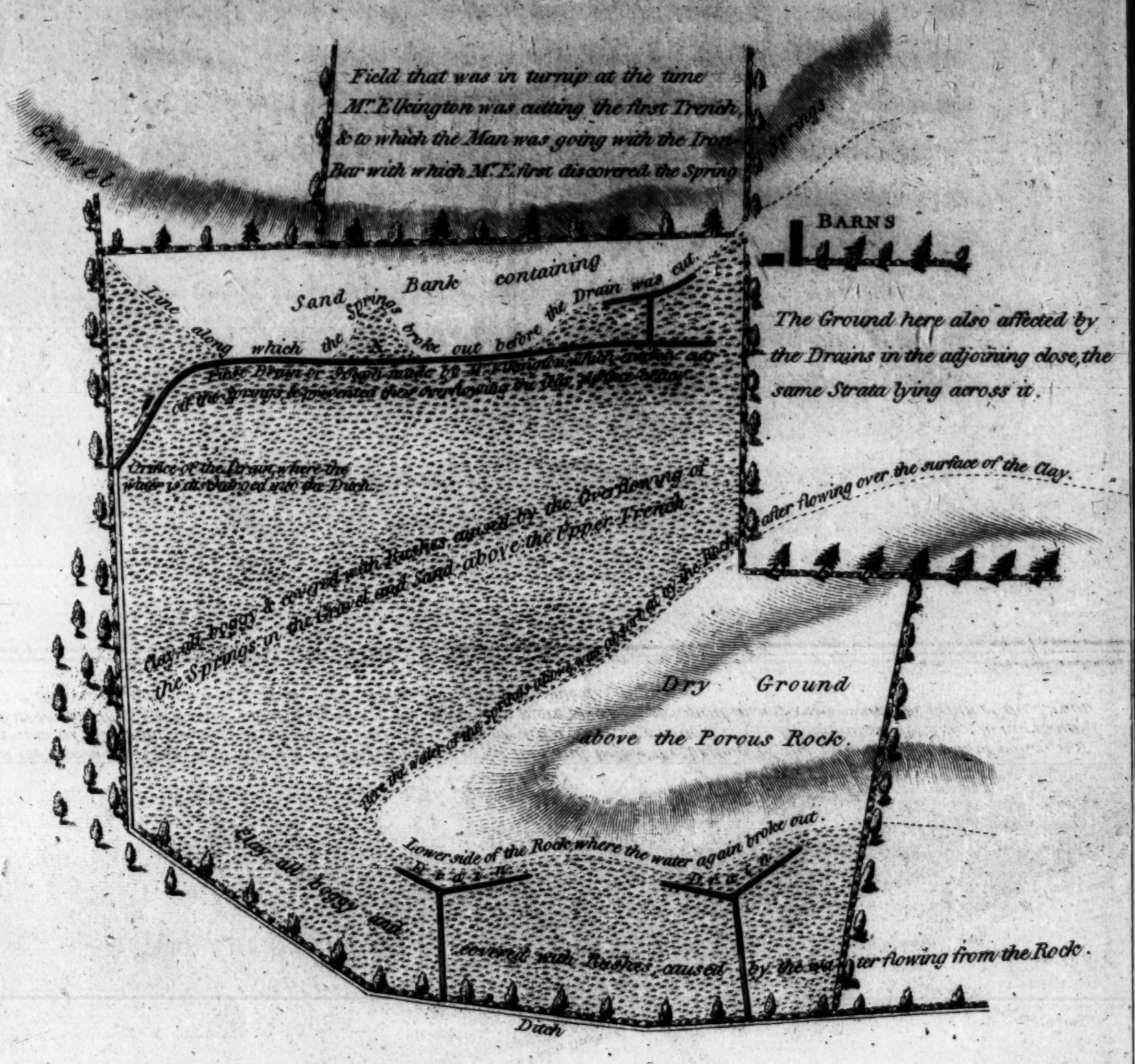
THE draining of one large tract of land may furniſh water for the accommodation of another, which, if collected in ſufficient quantities, may be converted to its improvement by irrigation. By the ſame means a more abundant and regular ſupply of water may be obtained, to drive mills and other machinery conſtructed for various purpoſes, and for ſupplying canals or artificial navigations, houſes, fiſh ponds, &c. It may alſo be applied, with great advantage, in the caſe of mines, by diminiſhing the quantity of water found in working them, as ſhall afterwards be ſhown.

G.R. III.
BRITISH MUSEUM

Plan of LONG HAROL PITS,

Part of the Farm of Prince Thorp in Warwickshire.

Being the FIELD in which Mr. ELKINGTON first discovered his MODE of DRAINING, An. 1764.



SECTION.

EXPLANATION

A. in the Plan, represents the place where the Clay pointed up on the surface above the line, and below the bottom of the Trench, the depth of which not reaching the Spring, induced Mr. Elkington to push down the Iron Bar, which at 4 feet below the bottom of the Drain, caused the Water to burst up, and thus was the first means that led him to think of applying the Auger as a more proper Instrument in such cases, where the depth of the Drain does not reach that of the Spring, and upon this all his future practise has been grounded.

Jas. Johnston del.

AN

ACCOUNT

OF THE

MOST APPROVED MODE

OF

DRAINING LAND, &c.

CHAPTER I.

Origin of the Diſcovery made by MR. ELKINGTON, *and the Means that firſt led him to a Knowledge of the Art.*

THE reaſon for introducing the ſubject of this chapter has been ſtated in the preface. It may be neceſſary to add, that the annexed plan was taken *ON THE SPOT*, in preſence of Mr. Elkington, for the purpoſe of aſcertaining the nature of the original diſcovery, and the explanation and information relating to it having been alſo received from Mr. Elkington *THERE*, and

from others of reſpectability in that neighbourhood, the veracity of it may be depended on. In the year 1763, Mr. Elkington was left by his father the poſſeſſion of a farm called Princethorp, in the pariſh of Stretton upon Dunſmore, and county of Warwick. The ſoil of this farm was very poor, and in many places ſo extremely wet, that it had been the cauſe of rotting ſeveral hundred ſheep, which was the firſt means that determined him, if poſſible, to drain it, which he began to do in 1764. The field in which he began was of a wet clay ſoil, rendered almoſt a ſwamp (and, indeed, in ſome places, a *SHAKING BOG*), by the ſprings iſſuing from a bank of gravel and ſand adjoining it, and overflowing the ſurface of the clay in the manner deſcribed in the annexed plan, which is a true repreſentation of it. In order to drain this field, he cut a trench about four or five feet deep, a little below the upper ſide of the bog, or where the wetneſs began to make its appearance; and after proceeding with it ſo far in this direction, and at this depth, he found it did not reach *THE MAIN BODY OF SUBJACENT WATER*, from whence the evil proceeded. On diſcovering this, Mr. Elkington was at a loſs how to proceed. At this time, while he was conſidering what was next to be done, one of his ſervants accidentally came to the field where the drain was making, with an iron crow or bar, which the farmers in that country uſe in making holes for fixing their ſheep hurdles. Mr. Elkington having a ſuſpicion that his drain was not deep enough, and a deſire to know what kind of ſtrata lay under the bottom of it, took the

iron bar from the ſervant, and after having forced it down about four feet below the bottom of the trench, on pulling it out, to his aſtoniſhment, a great quantity of water burſt up through the hole he had thus made, and run down the drain. This, at once, led him to the knowledge of wetneſs being often produced by water confined farther below the ſurface of the ground, than it was poſſible for the uſual depth of drains to reach, and induced him to think of applying an auger, as a proper inſtrument in ſuch caſes. Thus did the diſcovery originate from chance, the parent of many other uſeful arts! In this manner, he not only accompliſhed the drainage of this field, which ſoon rendered it completely ſound, but likewiſe all the other wet ground on his farm.

The ſucceſs of this experiment ſoon extended Mr. Elkington's fame, in the knowledge of draining, from one part of the country to another; and after having drained ſeveral farms in his neighbourhood with equal ſucceſs, he at laſt came to be very generally employed, has been ſince, and is now, in various parts of the kingdom, which ſhall be more particularly taken notice of in the ſequel. It is, indeed, now impoſſible for him to execute half the employment he has in hand, or to accept the numerous offers that are every day made to him. From his long practice and experience, he is now ſo ſucceſsful in the works which he undertakes, and alſo in judging of the internal ſtrata of the earth and nature of ſprings, that he can, with remarkable

preciſion, judge where to find water, and where to trace the courſe of ſprings that make no appearance on the ſurface of the ground. The rules on which he acts, with regard to theſe diſcoveries, will be afterwards explained in treating of the nature of wet ground cauſed by ſprings.

LASTLY, Within theſe few years paſt, ſince his practice has been ſo widely extended, and ſo generally ſucceſsful, he has drained in various parts of England, particularly in the midland counties, many thouſand acres of land, which, from being originally of little or no value, is now as productive as any in the kingdom, capable of producing the moſt valuable kinds of grain, or of feeding the beſt and healthieſt ſpecies of ſtock.

SOME have erroneouſly entertained an idea that Mr. Elkington's ſole ſkill lies in applying the auger for the *TAPPING OF SPRINGS*, without attaching any merit to his method of conducting the drains. The accidental circumſtance above ſtated gave him the firſt notion of uſing an auger, and directed his attention to the practice of draining, in the courſe of which he has made various uſeful diſcoveries, which are herein afterwards more fully explained. It will be ſufficient here to remark, that draining, according to his principles, depends upon three points:—*1ſt*, Upon finding out the *MAIN SPRING*, or cauſe of the miſchief, without which nothing effectual can be done. *2d*, Upon taking the level of that ſpring, and aſcer-

taining *ITS SUBTERRANEOUS BEARINGS*, a meaſure never practiſed by any till Mr. Elkington diſcovered the advantage to be derived from it; for, if the drain is cut a yard beyond *THE LINE OF THE SPRING*, you can never reach the water that iſſues from it, and, by aſcertaining that line by means of levelling, you can cut off the ſpring effectually, and conſequently drain the land in the cheapeſt and moſt eligible manner. The manner in which this is done will be afterwards deſcribed. And, *3dly*, By making uſe of the auger to reach or *TAP* the ſpring, when the depth of the drain is not ſufficient for that purpoſe.

In regard to the uſe of the auger, though there is every reaſon to believe Mr. Elkington was led to employ that inſtrument from the accidental circumſtance ſtated above, and did not derive it from any other channel; yet there is no doubt that others have hit upon the ſame idea, without being indebted for it to him. It is ſaid, that in attempting to diſcover mines by means of an auger, ſprings have been tapped, and the adjacent wet ground thereby drained, either by letting the water down, or giving it vent to the ſurface. The auger has alſo been made uſe of in bringing water into wells, by boring in the bottom of them, to ſave the expence of digging, eſpecially in Italy, where it is probable that the practice is very ancient. But, *THAT IT HAS BEEN USED IN DRAINING LAND BEFORE MR. ELKINGTON MADE THAT DISCOVERY, NO ONE HAS VENTURED TO ASSERT.*

In Dr. Nugent's Travels through Germany, printed anno 1768 (of which an extract will be found in Chapter V.), there is an account of a mode of draining land, on principles in ſome reſpects of a ſimilar nature, not indeed by the uſe of the auger, but by making pits. And, in a publication by Dr. James Anderſon, entitled "Eſſays on Agriculture and Rural Affairs," printed anno 1775, after deſcribing a mode of tapping the Doctor had adopted, by ſinking ſmall pits, he adds, "I have often imagined that the expence of digging theſe pits might be ſaved, by boring a hole through this ſolid ſtratum of clay, with a wimble made on purpoſe; but, as I have never experienced this, I cannot ſay whether it would anſwer the deſired end exactly."

Mr. Elkington, however, made uſe of the auger prior to the date of theſe publications, or to any hint he could poſſibly derive from any publication in the Engliſh language, though it is probable that, in ſo far as regarded *TAPPING OF SPRINGS FOR WELLS*, the uſe of the auger was well known in ſome parts of Italy. Buffon ſtates, "That, in the city of Modena, and four miles round, whatever part is dug, when we reach the depth of ſixty-three feet, and bore five feet deeper with an auger, the water ſprings out with ſuch force, that the well is filled in a very ſhort ſpace of time. This water flows continually, and neither diminiſhes nor increaſes by the rain or drought." Mentioning the different ſtrata that are met with to this depth, he

adds, "Theſe ſucceſſive beds of fenny or marſhy earth and chalk, are always found in the ſame order wherever we dig; and very often the auger meets with large trunks of trees, which it bores through, but which give great trouble to the workmen; bones, coals, flint, and pieces of iron, are alſo found. Ramazzini, who relates theſe facts, &c." *Buffon's Nat. Hiſt.*

CHAPTER II.

On the Principles of Mr. ELKINGTON's *Mode of Draining.*

IT is remarkable that the principles on which the draining of land depends, being ſo great a deſideratum in agriculture, ſhould have been ſo little known or attended to, or that the practice of it, according to theſe obvious principles, ſhould have been ſo much confined, while improvements in the other branches of huſbandry have been carried almoſt to the higheſt poſſible perfection.

HOWEVER intricate or abſtruſe it may hitherto have been conſidered, even by thoſe who were otherwiſe well informed in the theory of agriculture, of which it forms the moſt important branch; yet it will appear, from the following obſervations, to be founded on circumſtances the moſt plain and rational, and which, when reduced to practice, produce thoſe effects which a ſimple knowledge of the cauſe naturally points out.

WETNESS in land proceeds from two cauſes, as different in themſelves as the effects which they produce.

It proceeds either from rain water ſtagnant on the ſurface, or from the water of ſprings iſſuing over, or confined under it. On clay ſoils, that have no natural deſcent, wetneſs is commonly produced by the firſt of theſe cauſes; but, in a variety of ſituations, it may proceed from the latter.——But,

The principles of Mr. Elkington's art is ſo cloſely connected with the nature of ſprings, that, without a knowledge of theſe, and the cauſes producing them, it is impoſſible to practiſe it with either ſucceſs or advantage; for *SURFACE DRAINING*, where the wetneſs proceeds from ſubjacent water, is only alleviating the effect, in place of removing the cauſe. It will therefore be neceſſary, in the *FIRST* place, ſo far to aſcertain the nature of ſprings, and their connection with the formation of bogs, as to enable the practical drainer more eaſily to comprehend the theoretical part of Mr. Elkington's ſyſtem.

From its general external appearance, and by the perforations that have been made in it by quarries, wells, and other ſubterraneous pits, the earth is known to be compoſed of various ſtrata, which, being in their nature of oppoſite conſiſtence, are diſtinguiſhed by the names of *POROUS* and *IMPERVIOUS*. Thoſe ſtrata, which, from their more open compoſition, are porous, and capable of receiving the rain water that falls on them, include rock, gravel, ſand, and ſuch marles as are of an abſorbent quality. Clay, and a certain kind of gravel having a propor-

tion of clay in its compoſition, which, by binding and cementing the ſmall ſtones together, renders it equally cloſe and tenacious as clay itſelf; with ſuch rock as is of a cloſe and compact nature, without any fiſſures in it, are the principal ſtrata that moſt reſiſt the reception of water, and that are capable of retaining it on their ſurface till exhaled by the ſun, or carried off by ſuitable drains, and are termed impervious.

SPRINGS therefore originate from rain water falling upon ſuch porous and abſorbent ſurfaces, and ſubſiding downwards through ſuch, till, in its paſſage, it meets a body of clay or other impenetrable ſubſtance, which obſtructs its farther deſcent, and here, forming a reſervoir or conſiderable collection of water, it is forced either to filtrate along ſuch body, or riſe to ſome part of the ſurface, where it oozes out in all thoſe different appearances that are ſo frequently met with. This is evident from the immediate diſappearance of the rain water, as it falls, on ſome parts of the ground, while it remains ſtagnant on others, till carried off by evaporation; and from the ſtrength of ſprings being greater in wet than in dry ſeaſons. Hence, after inceſſant rains, they are obſerved to break out in higher ſituations, and, as the weather becomes drier, give over running out, unleſs at their loweſt outlets. The ſtrength of ſprings alſo, or quantity of water which they iſſue, depends chiefly on the extent of high ground that receives and retains the rain, forming large reſervoirs, which affords them a more regular

ſupply. Thus, bog-ſprings, or thoſe that riſe in valleys and low ſituations, are much ſtronger, and have a more regular diſcharge, than thoſe which break out on higher ground, or on the ſides of hills.

INDEPENDENT of theſe cauſes, there are certainly great ſprings contained in the bowels of the earth; otherwiſe, how could the many rivers that interſect it be ſupplied with ſuch vaſt quantities of water as they diſcharge, the rains falling on its ſurface, or the dews that deſcend, not being adequate for that purpoſe? But, as this may be conſidered among thoſe arcana of nature which have not yet been ſufficiently explored, and lying at too great a depth to affect the ſurface, it comes not within the limits of the preſent inquiry.

WITH the nature and cauſes of ſprings, that of bogs is intimately connected; for, where ſprings breaking out in the manner above deſcribed, run over a flat ſurface of clay, and cannot get off with ſufficient rapidity, or are not confined to a narrow channel; the ſuperabundance of water muſt cauſe the diſſolution of all the coarſe vegetables it produces, which, together with part of the natural ſoil itſelf, is formed into a peat earth, every year increaſing in depth; and the extent of ſuch bog or moraſs is according to the quantity of water, and to that of the flat ground on which it is formed *. The great ob-

* MANY and various are the conjectures reſpecting the origin of peat bogs; into

ject of Mr. Elkington's ſyſtem is, that of draining ſuch bogs, by cutting off entirely the ſource of the ſprings or ſubterraneous water that cauſes the wetneſs, either by flowing over the ſurface, or by its being long confined under it. If the ſprings have a natural outlet, the object of the drain is, to lower and enlarge it, which, by giving the water a more free and eaſy channel, will ſooner diſcharge and draw it off, or will reduce it to a level ſo far below the ſurface, as to prevent its overflowing it.

WHERE the ſprings have no apparent outlet, but are either confined ſo far below the ſurface, as to injure it by conſtant moiſture, or by oozing out imperceptibly through any ſmall pores of the upper ſoil; the object of the drain is, to give a proper vent to that water, and to extract more quickly and more effectually what has before been pent up in the boſom of the ſoil. The object of the auger, which in many inſtances is the *SINE QUO NON* of the buſineſs, is ſimply to reach or *TAP* the ſpring, and to give vent to the water thus pent up, when the depth of the drain does not reach it, where the level of the

---

the merits of which, it would be needleſs to inquire. Some ſuppoſe them to have been formed at the time of the general deluge, from the huge trees that are found in them, and from a variety of other circumſtances that lead to that ſuppoſition; but it is not ſo much the ſubject of this treatiſe to explain their probable origin, as the means by which ſprings or other accumulated water may be moſt eaſily cut off, from preſerving them in their preſent unproductive ſtate.

outlet will not admit its being cut to that depth, and where the expence of cutting ſo deep would be very great, and the execution of it very difficult.

ACCORDING to theſe principles, this ſyſtem of draining has been attended with extraordinary conſequences in the courſe of Mr. Elkington's practice, which ſhall be more fully explained in the after part of this Report. By it, not only the land in the immediate vicinity of the drain, but alſo ſprings, wells, and wet ground at a conſiderable diſtance, have been made dry, with which there was no apparent communication.

As the whole depends upon the ſituation of the ground to be drained, and the nature and inclination of the ſtrata of which the adjacent country is compoſed; as much knowledge as poſſible muſt be obtained of theſe before the proper courſe of a drain can be aſcertained, or any ſpecific rules given for its direction or execution. But all theſe circumſtances will be more particularly explained in deſcribing the parts of the operation with which they are connected.

CHAPTER III.

Drainage of Bogs and other Wet Ground cauſed by Springs.

THE draining of extenſive bogs, or tracts of marſhy ground injured by ſprings, is a part of the ſyſtem deſerving greater attention than any other, and is in every point of view the moſt important, becauſe many extenſive tracts of ground of this deſcription are at preſent loſt to every uſeful purpoſe to which they might be converted, from the miſtaken notion of thoſe to whom they belong, that their nature is ſuch, as to render them incapable of being drained. But however impracticable the drainage of ſuch bogs may appear, yet, by attention to Mr. Elkington's mode, they are not only eaſily drained, and at little expence, but when they are made dry, are by far the moſt valuable of any. The cauſe and formation of theſe bogs has been pointed out in the preceding chapter. They may be divided into two claſſes, according to their ſituation, and the different methods of draining them. Thoſe of the firſt claſs are eaſily diſtinguiſhed by the ſprings riſing out of the adjoining higher ground, in a regular line, along the upper ſide of the wet ſurface, which, together with the proper line of the drain,

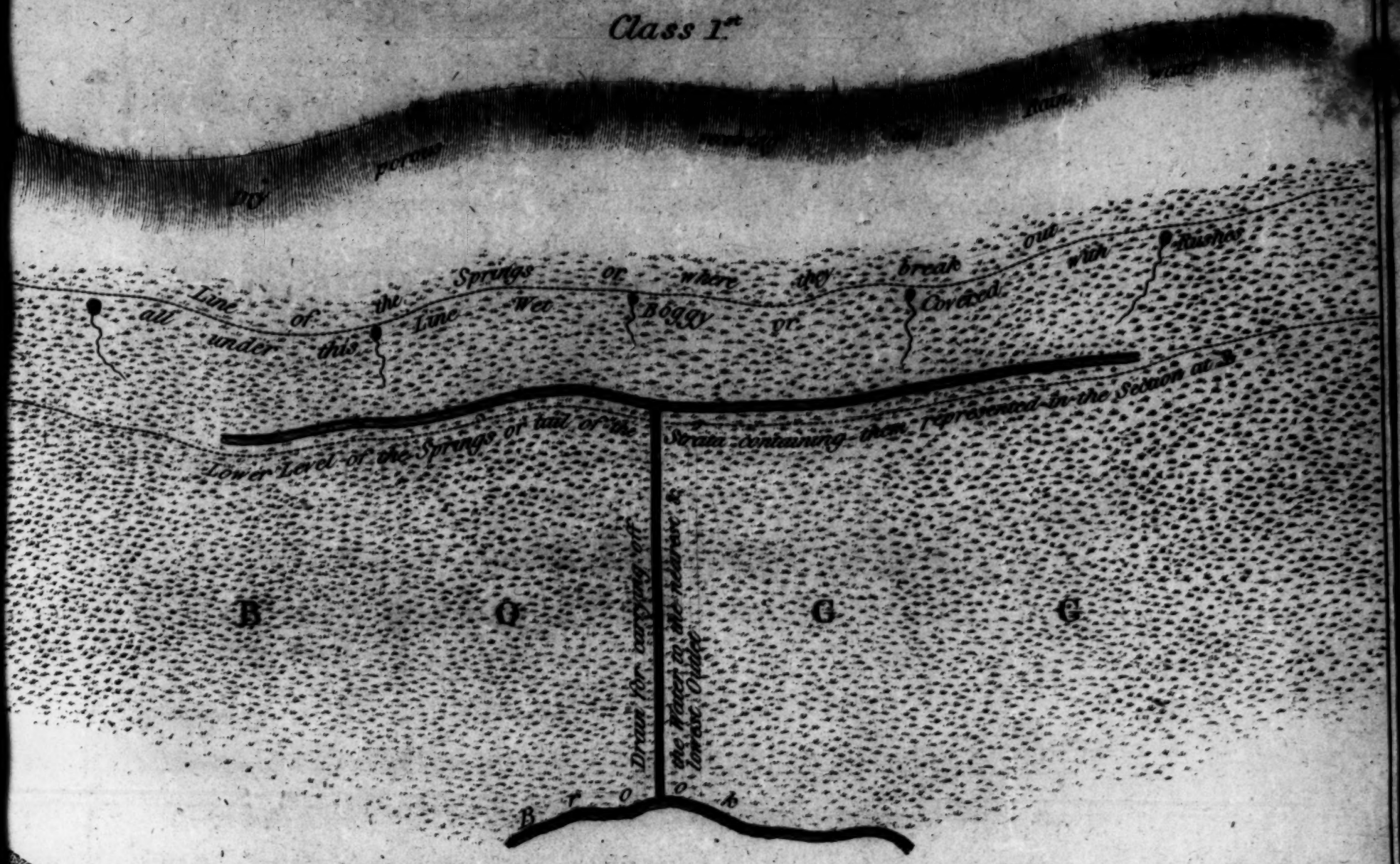
are delineated on the annexed plan (Claſs 1ſt). The ſecond claſs of *SPRING BOGS* * have the appearance of being ſtill more difficult to reclaim, although, in ſeveral reſpects, they are leſs ſo than the former.

IN theſe, the many ſprings that appear, are not confined to one regular direction along the upper ſide, but burſt out promiſcuouſly over the whole ſurface (eſpecially towards the lower ſide), forming quagmires that ſhake all around, and bend under foot like a ſuſpended cloth, over which it is dangerous for the lighteſt cattle to paſs, and which ſhow themſelves at a diſtance, by the verdure of the graſs which the *SPUDS*, or ſpots immediately round the ſprings produce. Of this luxuriant graſs ſheep are remarkably fond, and devouring it greedily, never fail being attacked with that incurable diſeaſe, the rot. This is mentioned the more particularly, not only as a ſufficient motive to recommend their drainage in ſheep walks, but (as has already been noticed) being one of the principal cauſes that firſt induced Mr. Elkington to attempt the drainage of a ſimilar bog, in which he fortunately made that diſcovery which was the baſis of his future practice. Under the peat earth, that for ten or more feet, forms the upper part of theſe bogs, is found

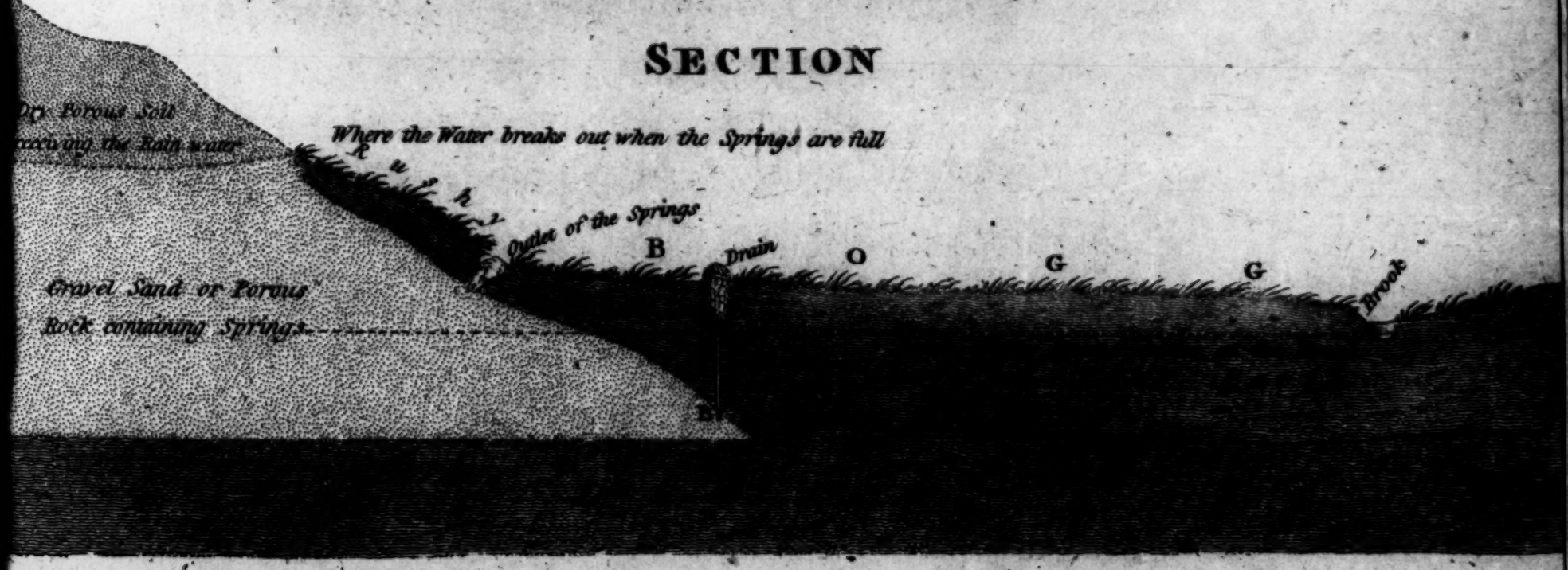
* So called in contradiſtinction to thoſe grounds that are wet and boggy, by retaining ſurface water; and alſo to ſuch *PEAT BOGS* or moſſes that do not originate from ſprings.

PLAN *representing the* DRAINAGE *of* BOGGS *caused by* SPRINGS.

Class 1st



SECTION



If the stratum of Clay where the Trench is cut, be thicker than the Level of the Orifice will admit the Depth of the Drain to be; (A. representing the Depth of it at that Level,) the remaining part of that Clay from A. to B. must be perforated by the Auger to the Tail or lowest point of the Sand or Rock at B, when the Spring will immediately rise up into the Trench by the pressure of its waters above the Drain's Level.

Johnston del.º

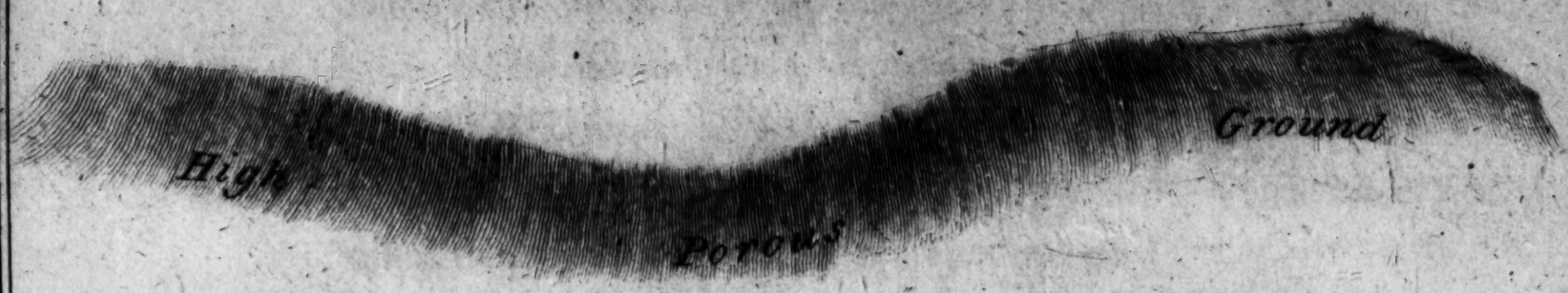
Neale sculp.t Strand.

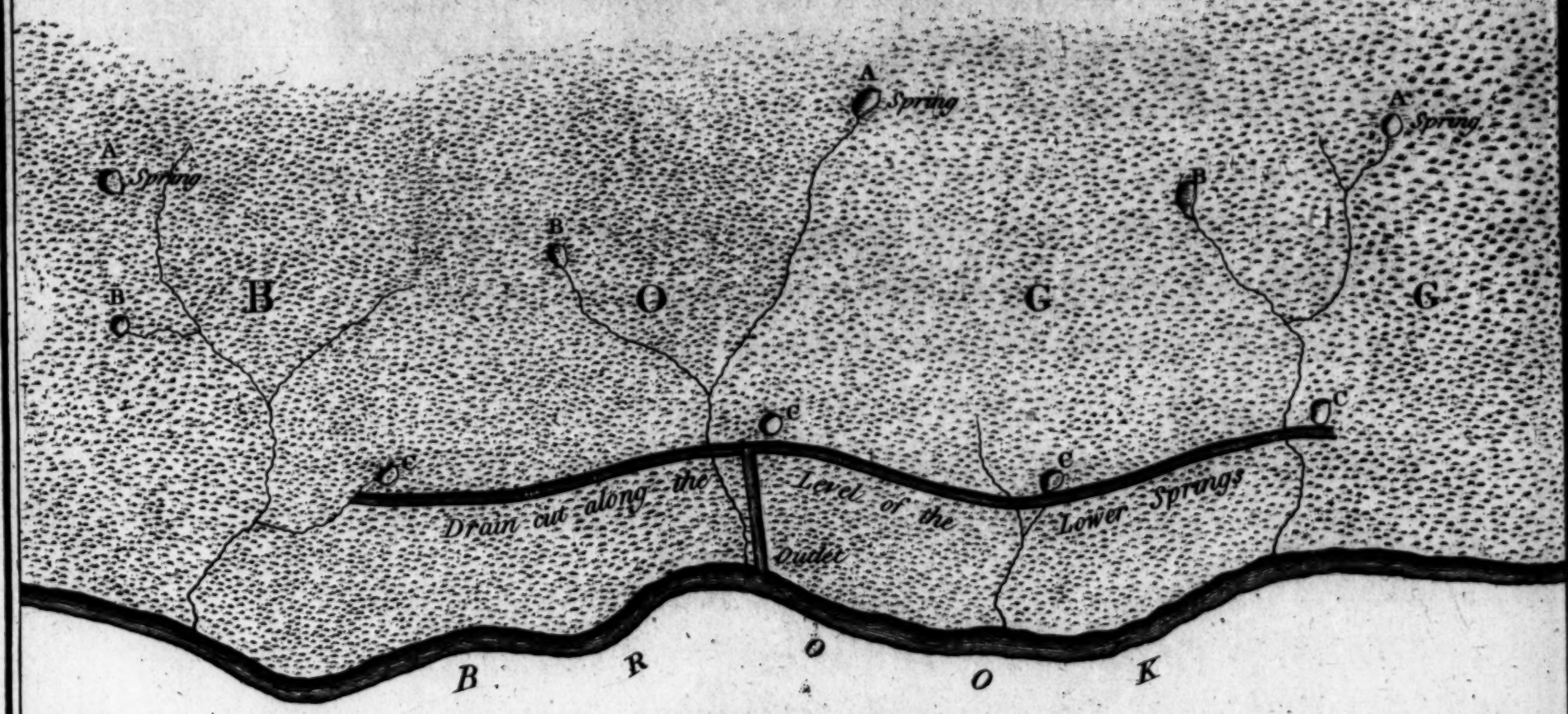

G.R. III.

G.R. III.
BRITISH MUSEUM

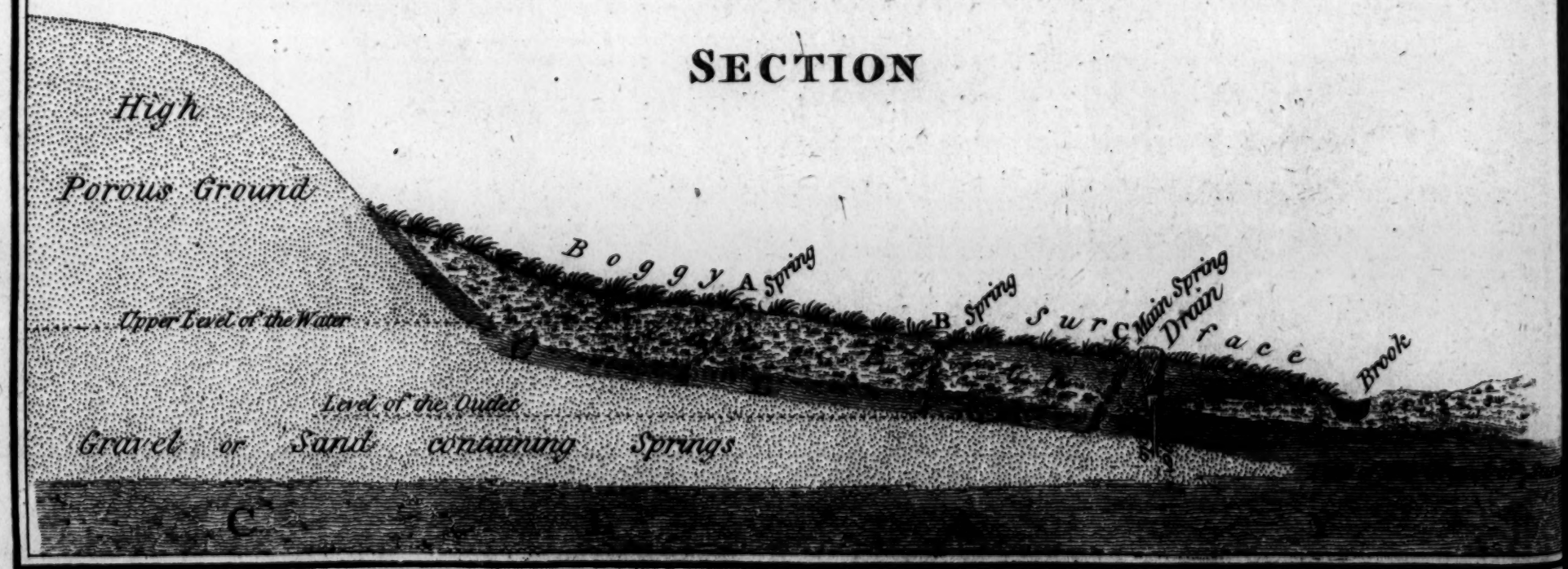
DRAINAGE of SPRING BOGGS.

Class 2.d





SECTION



J. Johnston del.ª

Neele sculp.ª 352 Strand

a bed of clay seldom of great depth, and under that a stratum of sand, gravel, or rock, if the adjacent eminences are composed of such. The clay bed immediately above, and between this and the peat, being in many places very thin, and in some degree porous, the constant pressure of water contained in the high grounds above, forces that under the bog, with which it is connected, through these more porous parts of the clay and peat, where it bursts up, forming those appearances just mentioned, which, together with the situation and course of the drain, are more clearly elucidated by the plan (Class 2d). Such are the general appearances that distinguish these two classes of bogs; but there is a variety of wet ground injured by springs, which neither being so extensive nor so much inclined to PEAT, to these, the term BOG* cannot so properly be applied; but, with regard to the mode of draining them, the same directions are equally applicable.

As there are a variety of circumstances that lead to a discovery of the proper line of the springs, and that must guide the direction of the trenches in draining these bogs, as well as every other description of wet ground proceeding from the

* Bog properly signifies a quagmire covered with grass, in which sense it differs from moss, the latter being covered with heath, and very often having no verdure on the surface at all. The greater abundance of springs in the former, also constitutes a material difference in their nature.

ſame cauſe; it will be proper to arrange them in the order in which they follow, previous to the execution of the work.

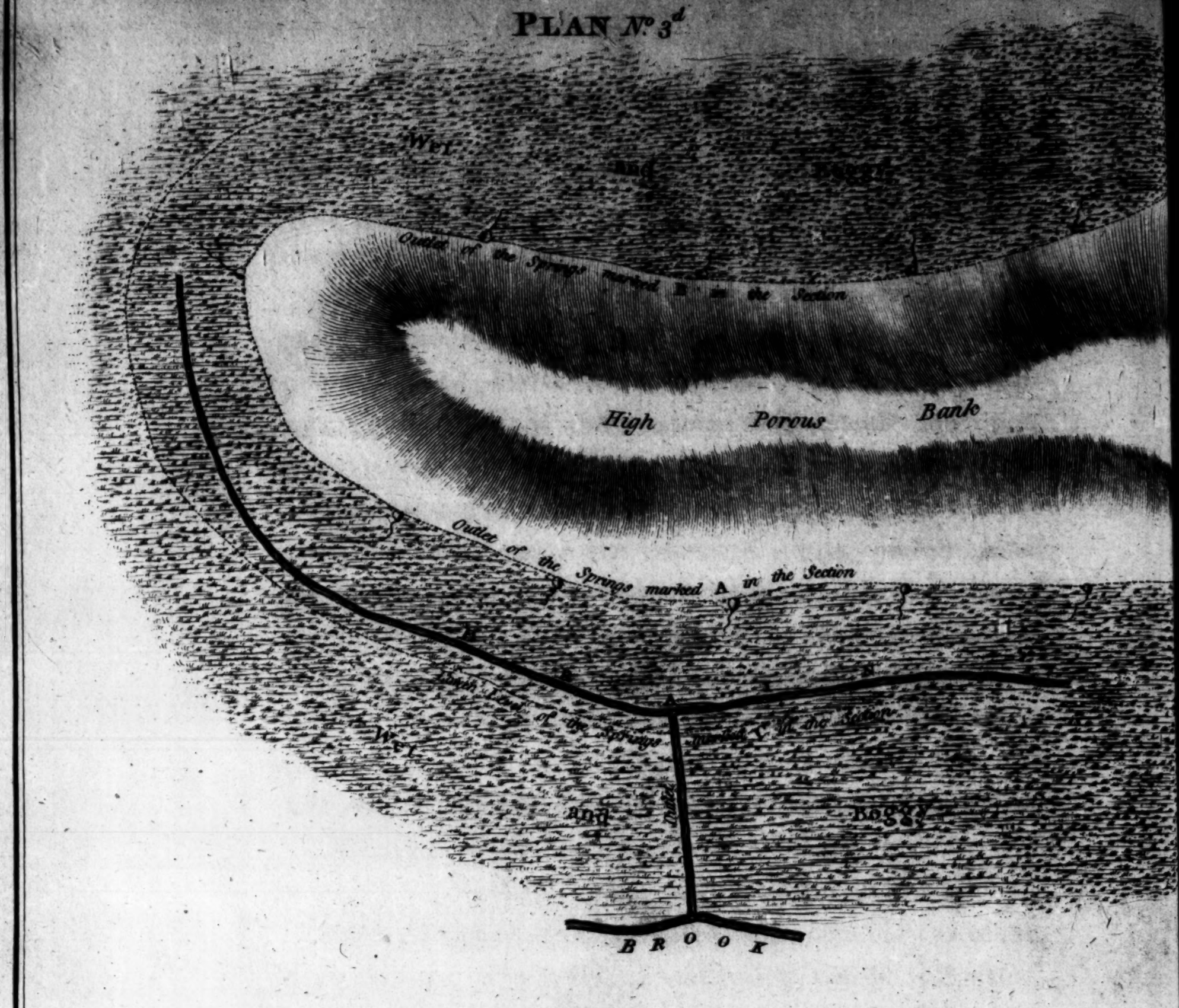
The firſt thing to be obſerved is carefully to examine the adjoining high grounds, in order to diſcover what ſtrata they are compoſed of, and alſo to aſcertain as nearly as poſſible the inclination of theſe ſtrata, and their connection with the ground to be drained; and to judge at what place the level of the *SAME SPRING* comes neareſt to that where the water can be diſcharged. By this means the length of cutting, and in ſome meaſure the quantity of water that the drain will iſſue, if it be wanted for any particular purpoſe, may be nearly aſcertained; for, the greater the extent of the high ground contiguous to the bog, the more conſtant and more abundant will the diſcharge be; and if only a ſmall hill or narrow bank, little water can be expected to run from it in dry ſeaſons, when the porous ſtrata can receive no ſupply from the rains.

The ſureſt way of aſcertaining the inclination and *LIE* of the different ſtrata, is by examining the bed of the neareſt rivers, and the ſides of the banks cut through by them, and any pits, wells, or quarries that may have been dug in the neighbourhood. Ruſhes and other coarſe aquatics * appearing on the

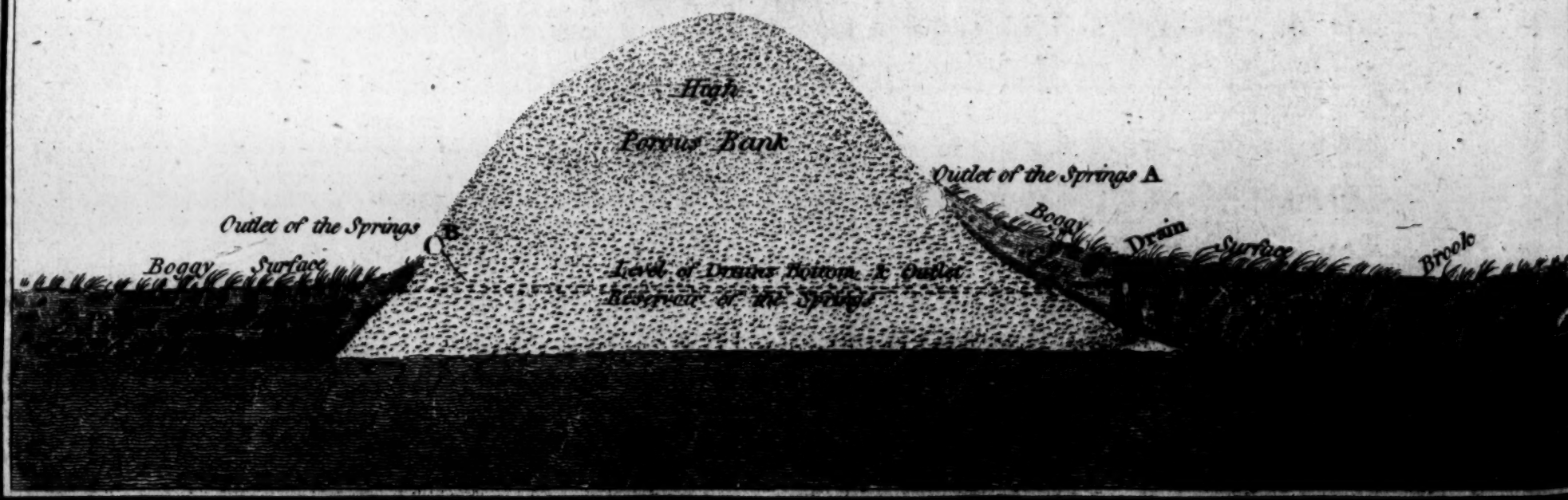
* Small alder buſhes, being of the ſame nature as ruſhes, and which grow naturally only on very wet ſoils, are ſure ſymptoms of the line of the ſprings, as they


G.R. III.

PLAN N.º 3d



SECTION



J. Johnston del.

ſurface may facilitate the inveſtigation; but theſe being often produced by ſtagnant rain water, where there is no ſpring, cannot be truſted to in caſes where more minute preciſion is neceſſary.

If the reſiſting ſtratum immediately under the porous one lie horizontally through the hill or bank, the ſurface below that level will be wet and ruſhy on both ſides, and the upper ſide of the wet ground will be found varying very little from a level all the way round. When this is the caſe, which frequently happens, a drain properly conducted on the one ſide of the hill will carry off the water that cauſes the wetneſs on both. See Plan, No. 3.

If the reſiſting ſtratum *DIP* or incline more to the one ſide than to the other, the ſprings will iſſue only at the lower ſide of that ſtratum, conſequently the one ſide of the hill will be wet, and the other dry.

It is of material conſequence to aſcertain which of the different outlets that may appear on the ſurface is the main ſpring, or that from which theſe outlets are ſupplied; for, by cutting off that, the others become dry, and is therefore one of the

---

either grow up immediately over the ſpring or below it, ſeldom higher, unleſs where the water *BACKS UP* to, when the ſpring is full.

principal circumſtances upon which the true direction of the drain depends. If, on the bank or ſloping ſurface from whence the ſprings proceed, they are found to break out at different levels, according to the wetneſs of the ſeaſon, and if thoſe loweſt down continue running while thoſe above are dry, it is a ſure ſign that all the different outlets are connected with, and proceed from, the ſame ſpring, and along the level of this under one the line of the drain ſhould be directed, which, if properly executed, all thoſe above will afterwards continue dry. This is called the *MAIN SPRING*, and thoſe above the overflowings of it. If the drain was to be cut along the line of the uppermoſt of theſe outlets, and the depth of it not reaching the level of thoſe below, the overflowings would only be carried off, the main ſpring ſtill continuing to flow, and injure the ground below the bottom of the drain, having a natural vent lower. Such has been the common practice hitherto of draining ground in this ſituation, where Mr. Elkington's method is not underſtood, and which was reckoned the moſt effectual and moſt approved mode. Wherever the uppermoſt ſprings made their appearance, there a trench was cut, *BETWEEN THE WET AND THE DRY*, as it is termed, which not being ſufficiently deep to intercept the water, others of the ſame kind were cut, one below another, the whole way down the declivity; and, being filled with looſe ſtones nearly to the top, each carried off a portion of ſurface water only, without ever affecting the ſpring that cauſed the miſchief. The conſequence of ſuch drains is, that they

render the ſurface drier while they continue to run, but ſoon choking up, and burſting out in different parts, the ground ſoon becomes equally wet, or more ſo, than before they were made. It is more difficult to drain this ground a ſecond time even in the proper manner, as the ſurface, by means of the former drains, being ſo much altered from its natural appearance, the true ſituation of the ſprings cannot ſo eaſily be hit on; and the frequent burſts of the old drains increaſe the perplexity.

IT frequently happens that the uppermoſt (if the *STRONGEST OUTLETS*) are the *MAIN SPRINGS*, and thoſe below only *LEAKAGES* *.

THEREFORE the ſame caution is neceſſary to aſcertain this before proceeding to mark out the drain, as from the *MAIN SPRING ONLY* the level muſt be taken, in the manner deſcribed in Chapter IX.

IN irregular banks, where the ground, owing to the perpendicular ſituation, or preſſure of water behind, has *SLIPT* or fallen down, the drain muſt be carried higher up the declivity

* THIS term implies, that ſome of the water from the main ſpring finds a paſſage through ſome opening in the *UPPER SOIL*, near the ſurface, and breaks out lower than the main ſpring, when it meets with reſiſtance from any bed of clay. By cutting off the main ſpring, this, of courſe, becomes dry.

than where the water has its apparent outlet, to the ſound ground that has undergone no change, and where the *REAL SPRING* will be intercepted; the water in the ſlipt ſand below, being only *LEAKAGES* from that above, but which is apt to deceive in cutting the upright trench *. When the main ſpring riſes in a ſteep bank a conſiderable height above the level of the brook, or place where the drain is to diſcharge itſelf, it is unneceſſary to cut a deep trench, or to lay a covered drain, all the way from the brook up to it; for, the deſcent being too rapid, and, if deep cut, by croſſing veins of ſand, that are always met with in ſuch ſituations, the bricks or ſtones with which the *SOUGH* or conduit of the drain is laid would be undermined by the rapidity of the current, which would alſo carry down a great quantity of the looſe ſand; but it ſhould be begun only ſo far down the bank, as, by *CUTTING IN LEVEL*, the drain may be ſix or ſeven feet lower than the outlet of the ſpring, or whatever depth is neceſſary for drawing down the water to ſuch a level, as it may diſcharge itſelf without riſing to the ſurface, or injuring the ground adjoining it. The remaining part of the cut down to the brook, either in a ſtraight or ſloping direction, may be left open, and need not be deep, but guarded from the cattle, and from the plough when the field is in tillage. If covered, it need not be deeper than two feet; and

* The upright trench is the drain from the outlet up to the croſs one, along the line of the ſprings.

G.R. III.
BRITISH MUSEUM

PLAN N.º 4.

Fig. 1

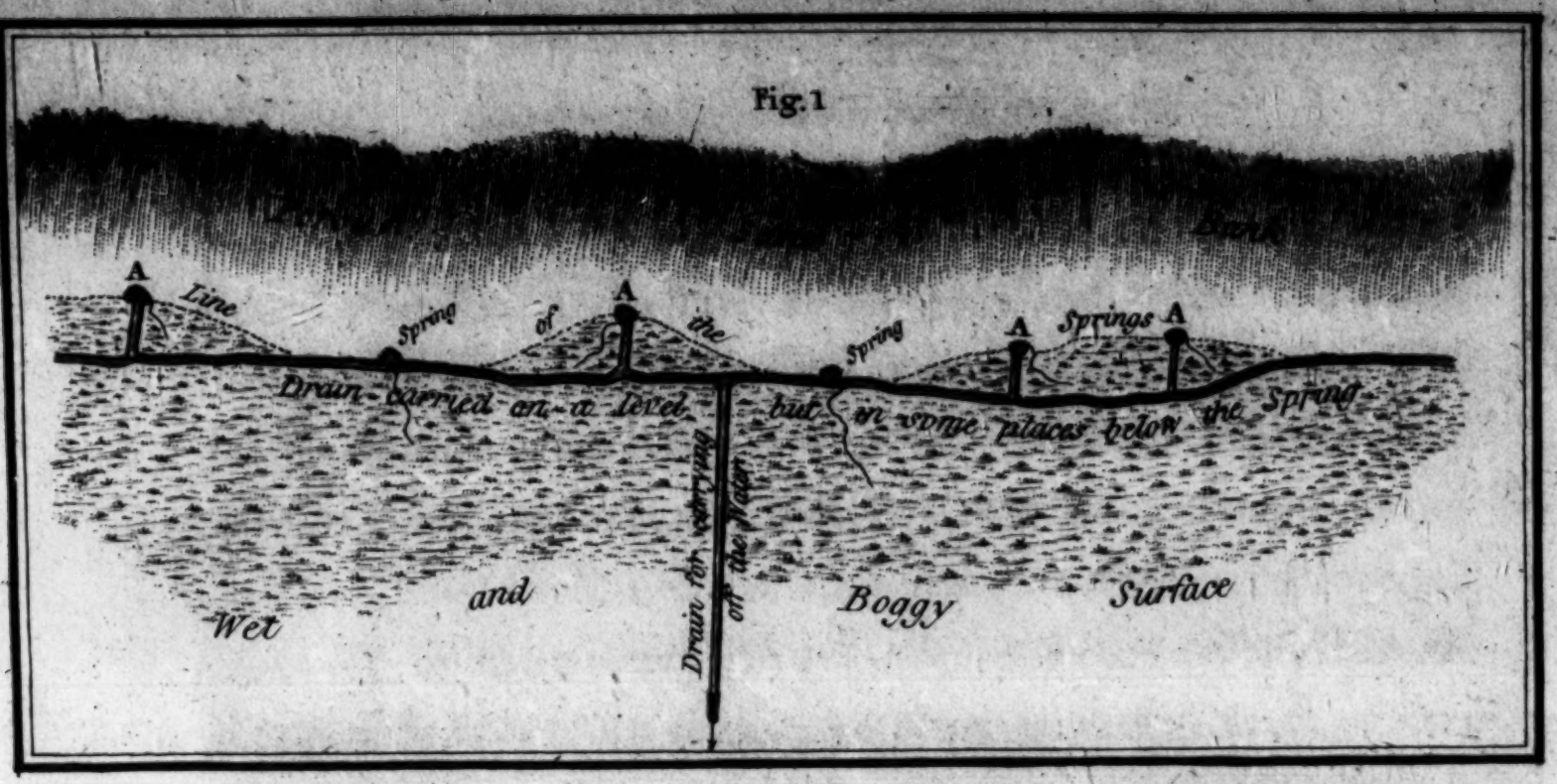
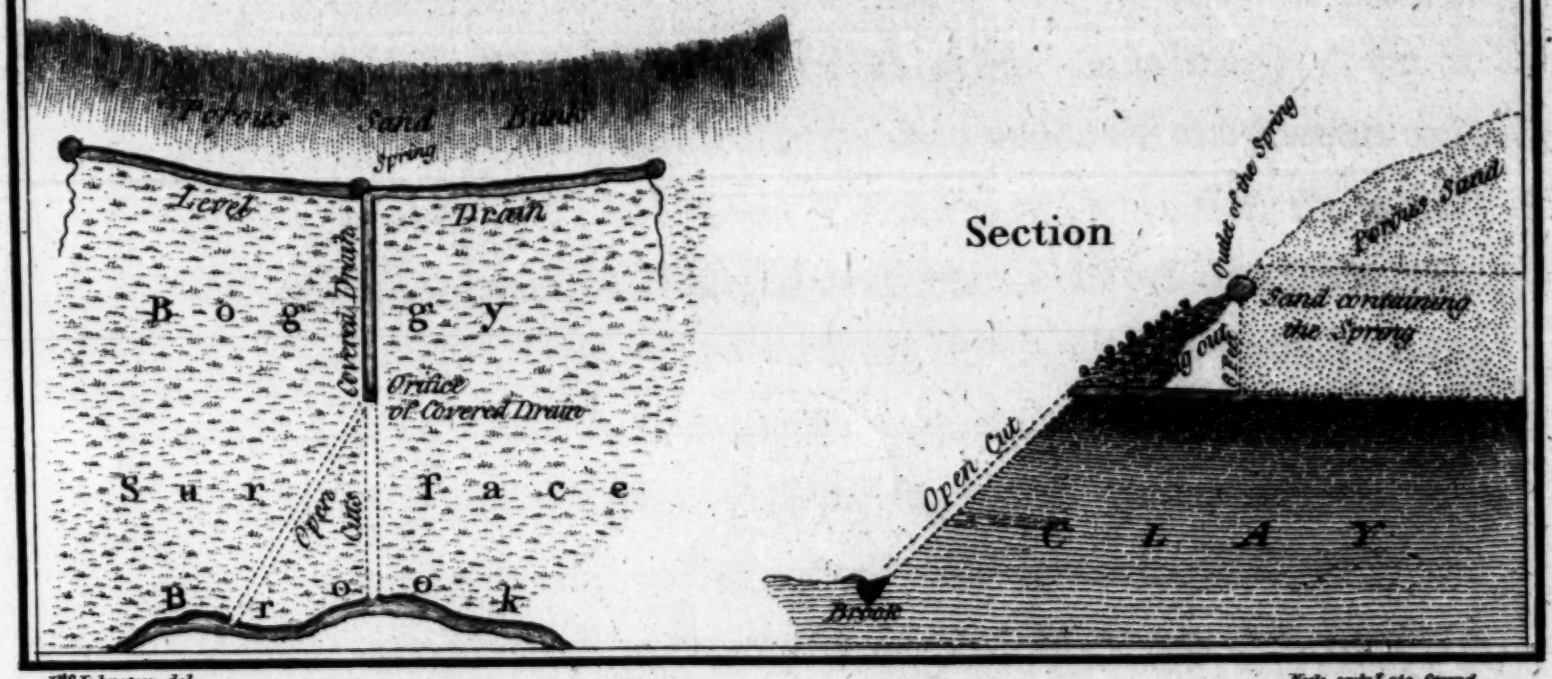
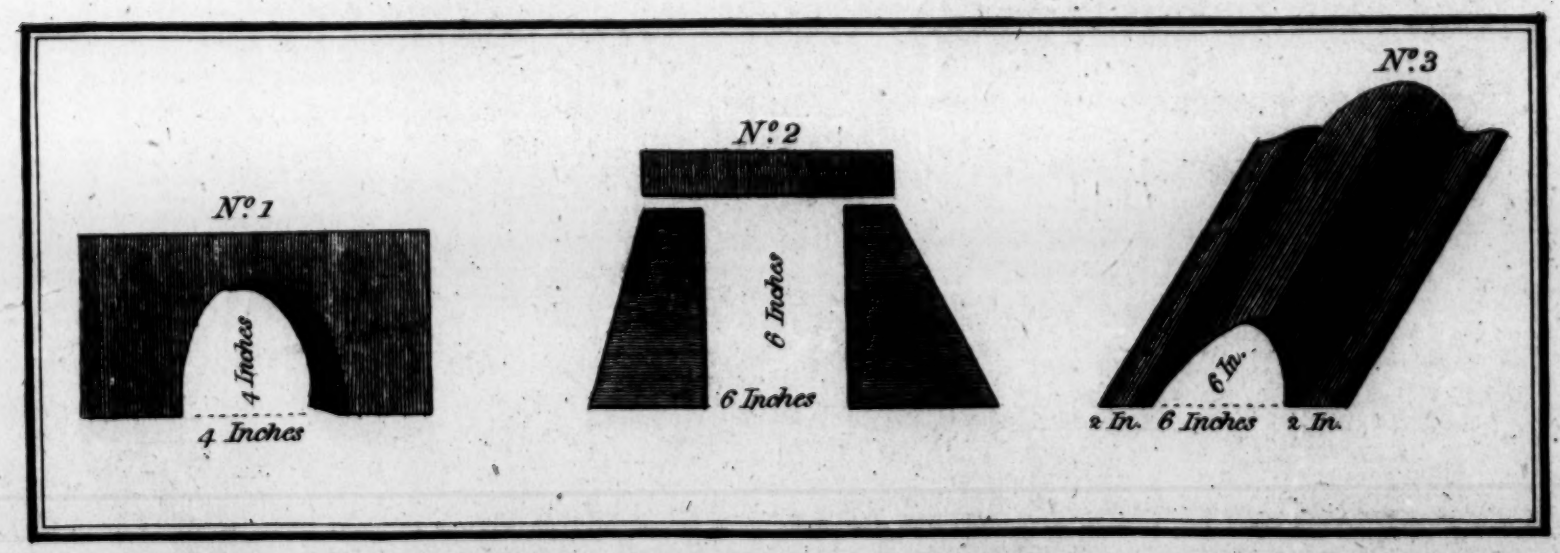


Fig. 2



J.no Johnston del

Neale sculp.r 362 Strand.



there is no occaſion for boring in any part of it. See fig. 2. and 3. Plan 4.

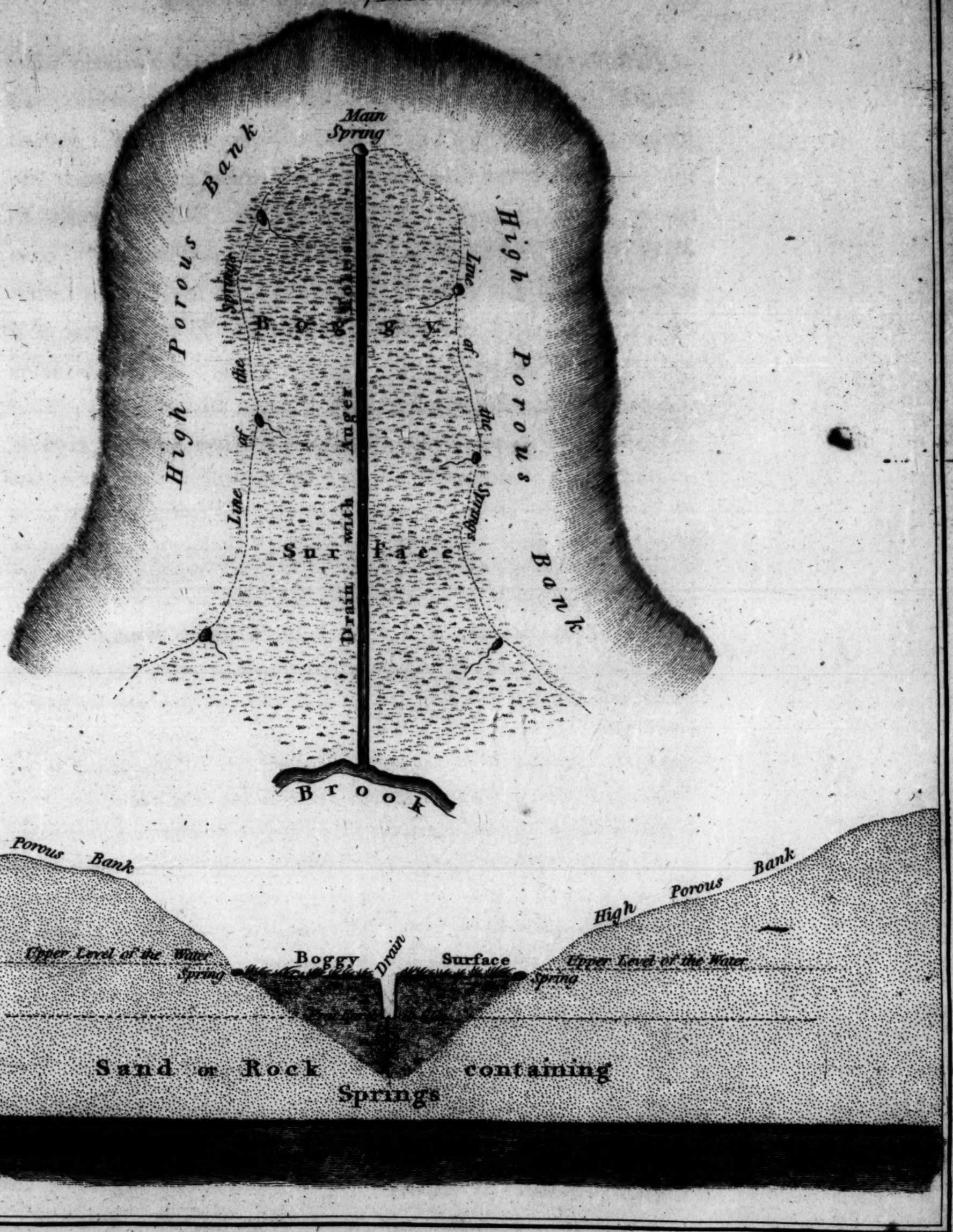
If there is any difficulty in aſcertaining the exact line of the ſpring and that of the croſs drain, *WHERE IT DOES NOT APPEAR ON THE SURFACE*, or when there is no apparent outlet from whence to take the level, in bringing up the leading drain for carrying off the water, it can be then diſcovered when it croſſes the proper line; and, without cutting any farther up, the croſs drain muſt be carried on that level, ſo far to each ſide along the *TAIL* or termination of the rock or ſand containing the water, as the ſituation of the ground and other circumſtances may require. And if, in cutting the croſs drain, the line marked out by the ſpirit level ſhould be found in ſome places to be below that of the ſprings; and if, in boring along that line, no water is found, then ſmall cuts muſt be made of the ſame depth, from the drain up to where the ſpring lies, as at the letters A in fig. 1. of Plan 4.; for if the drain is cut *BELOW THE LINE OF THE SPRING*, all poſſibility of reaching it, even by the auger, is loſt, as boring can have no effect where the ſubſtrata is clay, and where there is no *UNDER* water; and, if it is cut *ABOVE THE LINE OF THE SPRING*, it will require deeper cutting and boring to reach it, as there, for the moſt part, the ground riſes higher, and that part of the porous ſtrata below the drain may contain as much water as injure the ground, and which may eaſily paſs under the bottom of the trench between

the auger holes, and find vent below it. If the expanſe of the valley or bog betwixt two banks be ſo narrow, that the ſtratum of rock or ſand containing the ſprings unites within reach of the auger below the clay, one trench up the middle, with auger holes, will do the buſineſs, without any croſs or branch drains (See Plan No. 5.). Although the ſprings that injure ground in this ſituation break out of the banks all round, nearly on the ſame level, yet the refervoir from whence they proceed may be hit on in the middle of the valley, by boring through the ſuperincumbent body of clay that forces the water to riſe and ooze out along the upper edge of it, at its junction with the higher porous ground. The drain being cut in the hollow part of the ground, and the ſpring below bored into, it is evident, that the depth of the drain being ſo much lower than the natural outlet of the ſprings, the preſſure of water above that level (bottom of drain), will force that under the trench through the auger holes, or even, for ſome time, until the water ſubſide, it might be made to riſe higher than the level of its natural outlet. The conſequence of this will be, that the water of the ſpring having found, by means of the drain and boring, a new and eaſier channel, will ſoon abandon its former outlets, and ceaſe to overflow the ground that formerly lay below it *.

* In a valley belonging to Mr. Eccleſton of Scariſbrick in Lancaſhire, Mr. Elkington has executed a very remarkable drainage of the above kind. The ground was a

PLAN *representing the* **DRAINAGE** *of* **BOGGS**, *where the Sand Banks Unite.*

N.o 5th



J. Johnston del.t

Neele sculp.t Strand



In very wet ſwamps or bogs of great extent, it is neceſſary to have other cuts than thoſe that carry off the ſprings; for, although the upper ſprings, which are the principal cauſe, be cut off, there may be veins of ſand or gravel lower than theſe, out of which it is alſo neceſſary to extract the water. If the ground is to be divided into encloſures, the open ditches may be ſo directed as to hit on theſe lower collections of ſubjacent water, as well as to carry off any that might ſtagnate in the hollow parts of the ſurface *.

---

mere bog, ſo ſoft that neither horſe nor man could walk over it. It contained ſixty acres, which, after the drainage, gave 30l. of additional yearly rent, and the expence of executing the drains did not much exceed that ſum. An account of this drainage was communicated to the Board of Agriculture, about two years ago, by Mr. Eccleſton himſelf.

* Many extenſive tracts of land are wet and ruſhy from a cauſe that cannot be removed by any number of open or covered drains. This is called *HAUGH* or *HOLM LAND*, and lies along the ſides of brooks or rivers, which, having altered their courſe ſo often between the oppoſite banks, and depoſiting ſand and gravel as they recede from their laſt channel, the water always percolates through the ground thus formed to the level of its preſent courſe, keeping it ſo moiſt and wet as to produce ruſhes and other aquatics; and wherever a drain or pit is dug in ſuch ground, it immediately fills with water to the level of that in the river. Where the river has a quick deſcent, it is leſs apt to produce this effect; but where its current is ſlow, and the level of its ſurface little below that of the ground on either ſide, the ſoil will be more ſaturated with water. Any number of drains cut in any direction, can have no good effect while the river continues in its preſent courſe at ſuch a height. The only remedy therefor, where it can be done at a moderate expence, is, deepening and widening the bed of the river, the earth taken out of which will, at the ſame time,

THE next thing to be conſidered, is the conducting of the drain after the levels have been taken, and the true line of it fixed; and whether it ſhould be covered or open.

---

form an embankment on either ſide; for while it can riſe higher than the outlet of the drains and flow back into them, it renders the ground equally wet as before they were made, and the expence of making them is laid out to no advantage. Beſides being injured by the river water, ſprings, in many ſituations, iſſue from the bottom of the higher bank, and ooze through the ſoil higher than its level. The water of theſe can eaſily be cut off or lowered to the level of the river by a drain. In ſome caſes, the wetneſs proceeds entirely from ſprings, where the ſoil of the flat ground betwixt them and the river does not conſiſt of looſe gravel or ſand, but of a loam or clay mixture. In this caſe the water of the ſprings is reſiſted, and prevented from percolating through the ſoil in its way to the river, and is forced to riſe to the ſurface over which it flows. To drain this ground, a trench muſt be begun at the lower end of it, and brought from the river along the bottom of the bank from whence the ſprings iſſue. This trench ſhould be cut *BELOW THE LINE OF THE SPRINGS*, where it can be more eaſily done, and kept open to receive the river water in floods, which would *BLOW IT UP* if covered; and alſo any runs of water from the high grounds in time of rains. From this trench, ſhort covered drains muſt be cut up a little way into the bank, as repreſented by Figure 1ſt of Plate 4th. The bottom of theſe muſt be higher than the level of that of the open cut, to prevent any of the water in it flowing back into them. In theſe the auger muſt be uſed *TO TAP THE SPRINGS*, if the depth of this level does not reach the ſtratum containing the water. There will be no occaſion for any croſs drains betwixt the open cut and the river, as all the water that is intercepted will be carried along the bottom of the bank and emptied into the river at a lower level, unleſs the ground is of ſuch extent that it may be divided by croſs ditches into ſeparate encloſures. The open drain along the upper ſide will ſerve as a diviſion betwixt the meadow and higher ground. This ground is peculiarly ſituated, and its ſoil well adapted for watering after being drained.

If the land is to be encloſed, and as the line of the trench may ſerve as a proper diviſion of the ground, it may be made an open cut, if not, a covered drain; but it is firſt neceſſary to aſcertain which, as the depth, width, and other circumſtances may be regulated accordingly.

After finding the neareſt outlet where the water collected in the drain can be diſcharged, from that a trench muſt be brought up to the croſs one that is to be carried along the line of the ſpring; allowing a ſmall declivity of a few inches in every ten yards for the water to run.

In cutting the drain that is to carry off the ſpring, if, after paſſing the clay, there is a ſtratum of hard gravel betwixt that and the ſand containing the water, it is preferable to lay the *SOUGH* there, being a more ſolid foundation for it, and either to perforate the gravel with the *PUNCH*, or open ſmall pits through it with the ſpade; by means of which the water will flow up, and run as ſpeedily off, and with more ſafety, than if the ſough had been laid in the ſand itſelf, which would not only increaſe the depth and difficulty of working it, but, in many caſes, the level of the orifice will not admit of the drain's being cut to that depth. Alſo, if, in cutting the trench along the *TAIL* of the rock, the level of the orifice will not admit of its being cut ſo deep as to touch the rock, the clay or impervious

ſtratum that lies immediately above it muſt be bored through, when the water will flow up through the fiſſures of the ſtone, and through the auger-holes, into the ſough; but it is preferable, in caſes where the level will admit, to dig the drain through the clay, and ſo far into the rock as will furniſh ſtones for laying the ſough; and then the water will meet with leſs reſiſtance, and have a freer iſſue, than if the ſtone had not been opened nor broke. This will increaſe the expence of cutting the drain, but leſſen that of quarrying the ſtones elſewhere, and of carrying them to the place where the drain is made. Although, in the ground to be drained, there may be a ditch or other old water courſe, in which it may be practicable, by means of boring, to *TAP* the ſpring, yet it is better to make a new trench, in which the water of the ſpring only can have admittance; and where this muſt croſs any ditch or old water courſe, it muſt be ſecured by *PUDDLING* with clay, ſo as not to receive any ſurface water, which, by being augmented in time of floods, might ſoon blow up and deſtroy the ſough.

As the water thus obtained by means of boring may be converted to ſeveral uſeful purpoſes, as thoſe of irrigation, ſerving ſmall mills, canals, houſes, fiſh ponds, paſture fields, &c., caution is neceſſary in uſing the auger, leſt the water procured in one part of the drain may be loſt at another, in the ſame manner in which it was found, and in the endeavouring to procure

a greater ſupply; for, as mentioned in Chap. V., it may, by that means, be *BE LET DOWN FROM A WET INTO A DRY POROUS SUBSTRATUM.*

SUCH are the chief objects that require conſideration before beginning to cut the drains; the following directions will be uſeful in guiding the execution of them.

IF the drain is to be cut through a ſoft boggy ſoil, it is better to be open than covered, eſpecially where it may receive other water than that collected from below, and can at the ſame time ſerve as the ſide of an encloſure, or diviſion betwixt the upland and low grounds. Stones laid in ſuch drains are ſoon apt to ſink, owing to the ſoftneſs of the bottom, and the ſough may alſo be ſoon choked up. The width of a covered drain may be from three to four feet at top, and one and a half or two feet wide at bottom, thus allowing ſix or nine inches for each ſide ſtone, and ſix inches between for the paſſage of the water, forming a ſquare conduit *, being alſo ſix or nine inches in height. The depth is regulated by the level of the place where the drain is to empty itſelf, and the nature of the ground through which it is cut. The turf ſhould be firſt pared off thin, and laid to one ſide for after uſe, and all the mould thrown out to the other. The moſt difficult part of the

* This part of the drain is called the *SOUGH*.

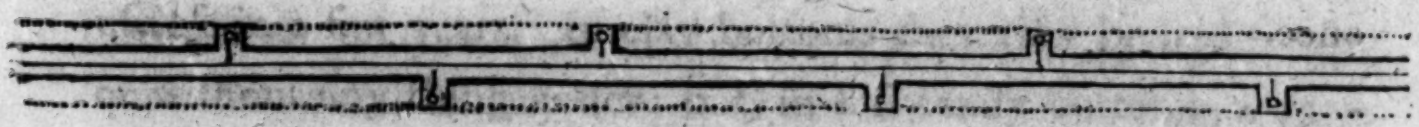
work is laying the fough in running ſands, where it is neceſſary to have the ſides of the trench ſupported with flat boards and props, which are removed forwards as they proceed in working, and which keep the ſides from falling in, and the looſe ſand from falling amongſt the ſtones with which the conduit is laid. If the ſough or conduit is laid with brick, a ſmall aperture muſt be left betwixt each to admit the water from the ſides of the drain, and the thin turfs muſt be laid above, graſs ſide downwards, to prevent the mould from getting through the openings.

THE turfs are laid, graſs ſide downwards, *IMMEDIATELY ABOVE THE STONES*, without any looſe ſtones above the laid ones, as the water is all collected from the bottom of the drain, very little from the ſides of it, and none admitted from the top.

IN quick or running ſands, turfs muſt alſo be laid in the bottom of the drain, under the ſough, to prevent the looſe ſand from flowing up, and to render the foundation of the brick or ſtone more ſecure in caſe of their ſinking.

IN theſe ſands, it is alſo better to dig a little into the ſides of the trench, off the line of the ſough, where the auger is to be uſed, and, after boring, to cover the places in the ſame manner as the reſt of the ſough, as the ſand thrown up by the ſpring can thus be more eaſily taken out with the hand till it ſubſides and gives over running, and is likewiſe off the main

current coming down the middle of the drain. The following is the figure of it.



That part of the fough above the auger-holes ſhould be left uncovered till the ſand is all thrown up, and the openings clear; but, till then, the ſand muſt be taken out, and the fough may afterwards be covered up with ſafety. Above ſome of the auger-holes, or at any other convenient part of the drain, a kind of funnel may be built to the top of the trench, whereby it can at any time be looked at, to ſee if the iſſue is clear, and if the quantity of water diminiſhes or increaſes. When the circumference of the auger-holes is not ſufficient to let up the quantity of water which the ſpring would otherwiſe iſſue; where it is not far from the bottom of the trench to the ſtratum containing the water, and where there is a bed of hard gravel intervening, impenetrable by the auger; holes muſt be dug with the ſpade down to the ſpring, and theſe holes filled up with looſe ſtones, firſt putting down a round ſtake in the middle, which, after the ſtones are filled in, muſt be drawn out, which leaves an opening for the water to flow up. No apprehenſion need be entertained of the holes made by the auger being filled up, whether the drain be open or covered, provided no other water is admitted; for, ſuch is often the force of the ſpring, that it

will throw up any earth or other ſludge that may accidentally get into it, and it can be injured only by the admiſſion of great quantities of ſurface or flood water coming upon it at once.

When flat ſtones can be got, they are preferable to brick; but there are ſeveral kinds of brick, beſides the common ſort, invented and uſed ſolely for the purpoſe of draining, in ſeveral parts of England, where the expence of ſtone would become greater. Of theſe the figures in the annexed Plate are ſome of the beſt kinds.

When ſmall drains are wanted, and when the water is to be conveyed to a houſe, &c., No. 1. is commonly made uſe of.

For larger drains, No. 2. and 3. are well adapted, eſpecially No. 3. *, lately invented by Mr. Couchman of Boſworth Temple in Warwickſhire, and with which Mr. Elkington has laid ſeveral drains.

They are laid ſingle, without one reverſed under; for, when

* The tax ought certainly to be taken off ſuch bricks as are uſed in draining only, and which cannot be applied to any other purpoſe, as thoſe above mentioned.

that is done, the water running on the under one occaſions a kind of ſludge, which in time becomes ſo encruſted on it, as totally to obſtruct the paſſage of the water, and render the work uſeleſs in a few years. In clay bottoms they may be laid ſingle, or without any thing under; but, in ſoft ſandy bottoms, a common building brick ſhould be laid under each ſide, to prevent them from ſinking down, and ſhould be ſo laid as to form a regular arch, the better to ſupport the preſſure above from breaking them. They may be conſtructed in the above ſhape, to any dimenſions ſuitable to the quantity of water the drain is to convey.

ALTHOUGH the earth that is thrown out of the drain ſhould, when filled in again, be conſiderably higher than the ſurface of the ground on each ſide, it muſt remain ſo; for, in a year or two, it will ſubſide to the level of the ſurface on each ſide. What remains may be ſpread or laid in ſome adjoining hollow; for, if levelled at firſt, the earth ſinks down, and the rain, by that means lodging in the hollow and ſubſiding downwards, may injure the ſough.

WHILE the drain is cutting in very wet peat ſoils, the ſurface water, or what may ooze from the ſides before coming to the ſpring, muſt be ſtopped here and there, and when let out to run through the ſough, a turf muſt be laid ſo as to prevent any ſludge which it may bring down from running through along

with it. When trees, eſpecially aſh, happen to be in the courſe of the drain, they muſt be entirely GRUBBED up, otherwiſe the roots will get into the ſough, and expanding through the joints of the ſtones, will ſoon put a ſtop to the paſſage of the water.

WHEN the water iſſued by the drain becomes of a red OCHRET colour, it indicates a ſtagnation either from the above cauſe, if amongſt planting, or from ſome part of the ſough having fallen in, which ſhould be ſpeedily repaired, otherwiſe the ground will ſoon become equally wet as before.

LASTLY, The mouth of the drain ſhould be carefully railed in, or otherwiſe guarded, to prevent the cattle from trampling it or choking it up, being fond of drinking there for the ſake of the cool water, even although there be watering places in the field; and where there is any defect of this kind, it ſhould immediately be remedied. The firſt ſymptoms of the drain's having effect, and which ſoon appear when the ſpring is properly TAPPED, are, that all the SURFACE DRAINS that may have formerly been made, and alſo any adjacent pits, ditches, or places to which it may have BACKED UP, immediately become dry and remain ſo afterwards.

ON the whole, it appears from the foregoing obſervations, that this mode of draining bogs, or land injured by ſubterraneous water, is by far the moſt effectual of any that has yet

been ſuggeſted; and that ſuch ground may be made completely dry, by *CUTTING OFF ONE SPRING ALONE*, with which the particular place to be drained may have no apparent communication, but which may be ſo connected *UNDER GROUND*, that from it all the others derive their ſource; and being therefore the *PRINCIPAL CAUSE* of the whole, *TO HIT ON IT* ſeems the chief deſideratum of the buſineſs. Of this, there are many inſtances in Mr. Elkington's practice, where, by a few auger-holes hitting on the particular ſpot where the *LOWEST PART OF THE MAIN SPRING LAY*, a conſiderable extent of ground, with which his drain had ſeemingly little connection, has been laid dry, to the aſtoniſhment of thoſe who have ſeen it, and furniſhing a ſubject of incredibility to many who have not.

AT Odſtone Hall in Leiceſterſhire, a very remarkable inſtance may be ſeen. A conſiderable tract of wet marſhy ground of very little value, divided in the middle by a ſmall river, he ſo completely drained, by making a ſmall trench at one ſide, and by boring in it, that the part of the marſh on the oppoſite ſide of the rivulet, which was at a very conſiderable diſtance from the drain, became in a ſhort time equally dry with that where the cut was made, has continued ſo ever ſince, and from being formerly of little or no value, is now converted into excellent *WATER MEADOW*, producing, *WITHOUT MANURE*, abundant crops of graſs.

At Madely near Newcaſtle in Staffordſhire, there is a very conſiderable bog of ſome hundred acres, the drainage of which was always deemed impracticable, being of ſo wet and ſoft a nature that no cattle could paſs over any part of it, till of late, Mr. Elkington having obtained a leaſe of it for a certain number of years, has, by means of very little cutting and expence, ſo effectually drained it, that it may now be conſidered not only one of the moſt wonderful undertakings of the kind ſo eaſily accompliſhed, but is alſo, from the other improvements making on it, likely ſoon to become one of the moſt productive farms in that part of the country.

At Wooburn in Bedfordſhire, he has lately accompliſhed the drainage of two extenſive bogs belonging to his Grace the Duke of Bedford, in a manner attended with little expence, although they were formerly reckoned irreclaimable.

By drains, too, which he has made, pits and wells at a great diſtance have been laid dry, and diſtant ſprings have abandoned their former courſe.

Many more inſtances of remarkable drainages of the ſame kind, executed by Mr. Elkington in different parts of England, might be mentioned; but, as they are all founded on the principles I have explained, and executed in the ſame manner, the

preceding may ſuffice as evidences of their ſucceſs, being *FACTS* no leſs true than aſtoniſhing, and which are taken notice of in the Agricultural Reports of the counties to which they belong, as ſhall be ſhown in the ſequel.

F

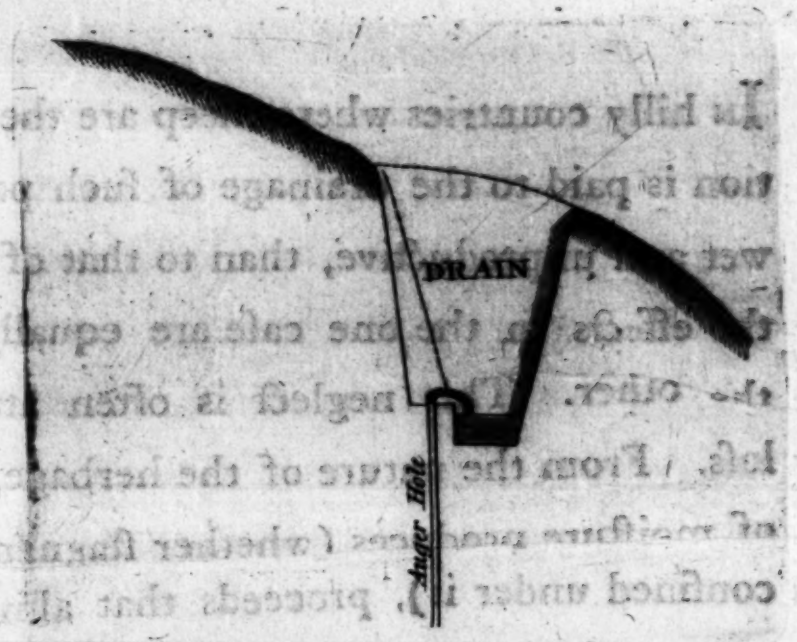
CHAPTER IV.

Drainage of Hills and Sheep Paſtures, with Obſervations on the Means of procuring and raiſing Water for Wells, &c.

In hilly countries where ſheep are the ſtaple produce, leſs attention is paid to the drainage of ſuch parts of their walk as are wet and unproductive, than to that of arable ground, although the effects in the one caſe are equally beneficial with thoſe in the other. This neglect is often attended with conſiderable loſs. From the nature of the herbage, which a ſuperabundance of moiſture produces (whether ſtagnant on the ſurface or long confined under it), proceeds that almoſt incurable malady the rot, to which ſo many thouſands of valuable animals fall a ſacrifice. For this, draining is the moſt infallible preventative, and in ſuch ſituations it is attended with little expence, as the drains may, for the moſt part, be left open, with only here and there, covered paſſages over which the ſheep may croſs with ſafety.

And, although in places where the depth of the cut does not reach the ſpring, the auger muſt be applied; no apprehenſion need be entertained of the holes filling up where the drain is

left open, for the force of the ſpring will, of itſelf, throw up any ſand or ſludge that may get into them, provided no great quantity of flood or ſurface water is admitted: but, the better to ſecure them againſt any obſtruction, ſmall openings may be made along the upper ſide of the trench, and in theſe the perforations may be made, leaving the mouth of the auger holes about ſix inches higher than the bottom of the drain, which will be without the reach of the water that may be accumulated in time of rains. Thus,



FROM the irregular diſpoſition of the component ſtrata, the ſides of many hills are covered with alternate patches of wet and dry ſoil. By the appearance of the ſurface, and by the vegetables it produces along the declivity, the internal ſtrata, and manner in which they lie, may often be aſcertained with ſuch a degree of preciſion, as to guide the direction of a drain without inveſtigating *BELOW THE SURFACE;* for, the difficulty or facility with which ſuch ground may be drained, depends entirely upon the *LYE* of the different ſtrata of which the hill is compoſed, and upon the perpendicular or horizontal inclination of the rock or body in which the water is contained. If the

rock lies in a horizontal direction, all the different outlets or ſprings that appear on the ſurface, may proceed from, or be connected with, the ſame body of water, and may all be *DRIED UP*, by cutting off or letting out the main body of water that ſupplies them, at the lower part of the reſervoir or place where the water would of itſelf run off more eaſily, if it was not confined under an imperviable covering of clay. But,

WHERE the rock lies in a perpendicular manner, and contains only partial collections of water amongſt the more open fiſſures of the ſtone, which empty themſelves at numberleſs outlets unconnected with one another; it would be prepoſterous to attempt cutting them off by *ONE DRAIN*, or by *TAPPING* any particular one of them, without a drain being cut into each. See Plan marked No. A. Fig. 1ſt.

IN this manner, it is better to cut the main drain *ALL IN THE CLAY*, with ſmall cuts up to each outlet, than along the dotted line or place where the ſprings break out, as it would in that direction be *TOO MUCH IN THE ROCK* and difficult to cut, from the nature and inclination of the ſtone. Where the water iſſuing out along the dotted line, can by means of the auger be hit on in the main drain at the points A A A, it will be more effectually cut off; but if that is not practicable, the depth of the ſmall cuts will reduce it to ſuch a level as prevent its overflowing or injuring the ſurface below.

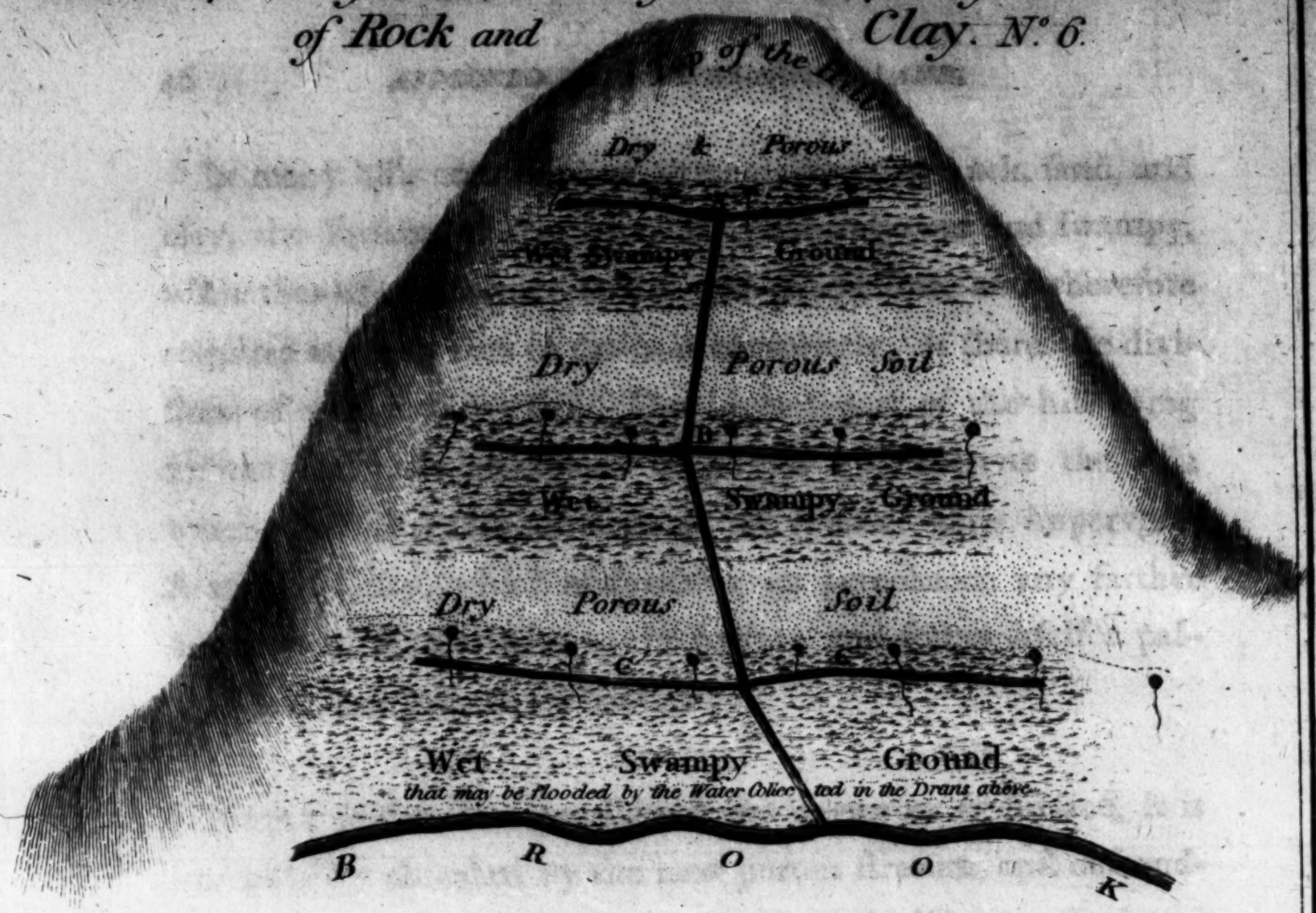
In many hills compoſed of alternate ſtrata of rock, ſand, and clay, the ſurface of the latter is commonly wet and ſwampy, while that of the former is dry and productive, and therefore requires as many cuts to drain it completely, as there are diviſions of wet and dry ſoil. The higheſt part of the hill being for the moſt part compoſed of porous ſoil, receives the rain water which deſcends through it till it meet ſome impervious ſtratum, as clay, which obſtructing its percolation any farther downwards, it then riſes to the ſurface and forces itſelf a paſſage over that impaſſable ſtratum.

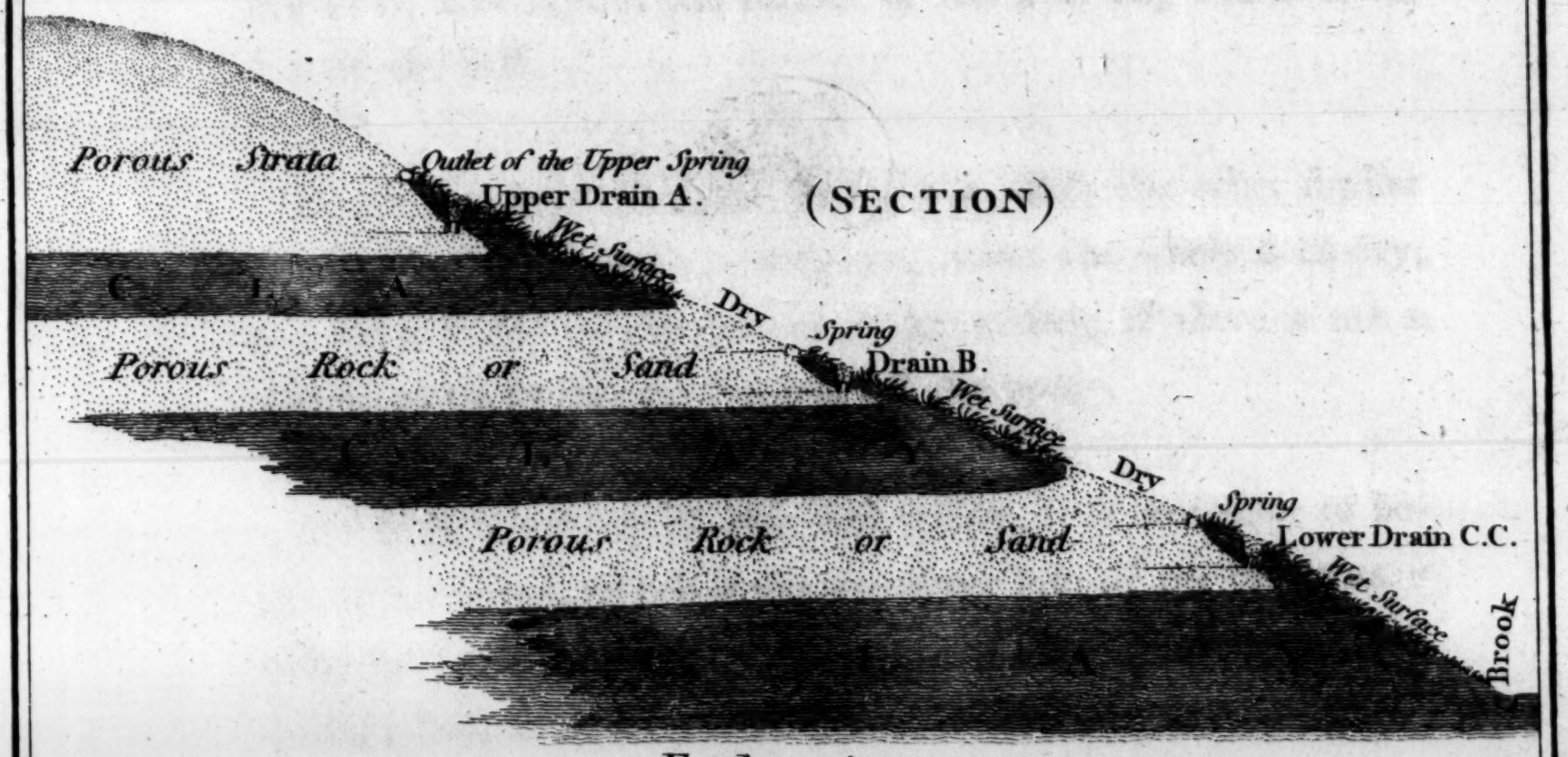
After it has thus overflowed the *upper clay* ſurface, it is immediately abſorbed by the next porous ſtratum, and deſcending into it in like manner as above, it again iſſues at the lower ſide of it, and injures the ſurface of the next clay bed as it did that of the firſt.

In this manner the ſame ſpring will affect the other ſimilar ſtrata of which the hill is compoſed, down the whole declivity, and form at laſt in the hollow a lake or bog, if there is not a proper outlet or deſcent to carry off the water.

To drain a hill ſide of this deſcription, it is neceſſary to begin by making a trench along the upper ſide of the *uppermoſt* ruſhy ſoil, which will have the effect of cutting off the higheſt ſpring; but, as the rain falling on the next porous ſoil ſubſides

PLAN *representing the* **DRAINAGE** *of a* **HILL** *composed of alternate Beds of* **Rock** *and* **Clay**. *N.° 6.*





Explanation.

The covering of tough soil that overlaps the tail or lower part of the Stratum containing the Spring, is formed of the fine particles of earth washed down from the Soil above, by that part of the Rain, which in heavy showers does not subside into the Ground. This accumulating upwards, is the cause why Springs back up, and why rushes & other Aquatics continue to vegetate higher up the Acclivity. The Drains being cut through this covering into the lower part of the Reservoir, reduce the top of the Springs, to a level so far below their former outlet, as entirely to prevent their afterwards overflowing the Ground below.

Jn.° Johnston del.t

Neale sculp.t Strand.

to the loweſt part of it and forms another ſpring, a ſecond cut is neceſſary there to prevent that water from injuring the ſurface of the next clay bed. Thus, ſimilar cuts will be requiſite lower down the deſcent, ſo far as the ſame ſprings and appearances continue to injure the ground, which may produce a quantity of water ſufficient to irrigate the lower ground, or which may be uſeful in ſome other reſpect. See Plan, No. 6.

In ſome hills, the ſtrata of which they are formed, lie ſo regular, that it is practicable to extract the water from either ſide on the ſame level, which would be of very conſiderable advantage in draining the one ſide and irrigating the other; for there is often found on the one ſide a wet ſwamp, and on the other, the ſoil too dry. This is owing to the bed of clay that upholds the water not lying horizontally, but *DIPPING* more to the one ſide than to the other, and by the one (the dry) ſide being *OVERLAPT* by a covering of clay, whereby the water is forced to iſſue at the open ſide; but, if an outlet is given to it on the *DRY SIDE* by means of a drain, lower than that from which it flows on the wet ſide, the courſe of the ſpring may eaſily be diverted.

The oppoſite ſide being porous and covered with ſand, will act as a reſervoir to receive the rain waters, which will afterwards flow through the opening made in the clay. This may be of great uſe in ſupplying a houſe with water that is ſituated

on the dry ſide of the hill, and ſave the additional expence of conveying it in another manner *. See Plan marked No. A. Fig. 2.

A SPRING in a low ſituation adjacent to higher ground may be raiſed to ſupply a houſe, or for any other uſeful purpoſe, although much below that level, by confining it in a pipe or brick chimney.

THE reſervoir from whence the ſpring or outlet of water is ſupplied being confined, and pent up between two impervious ſtrata, and the upper part of it extending perhaps to a conſiderable height and diſtance in the high ground, it is evident that, if a perforation is made through the ſuperincumbent ſtratum into the *TAIL* or loweſt part of the porous ſtratum containing the ſpring, the water may be raiſed, by confining it, nearly as high as the level of the head of the reſervoir. See Fig. 3.

OF this there are ſeveral inſtances in Mr. Elkington's practice, particularly near Warwick, where he raiſed the water procured from draining a low meadow, into a mill lead a conſiderable height above the level of the drain. The drain is cloſely

* CARE muſt be taken in conducting the drain for conveying water to ſupply a houſe, &c. not to cut it, or bore in it, ſo deep as to reach a porous ſtratum, otherwiſe the water that may have been found at one place, may, by the ſame means, be loſt at another. Puddling may in ſome degree ſecure it, but not in every caſe.

built with brick, and puddled above with clay, to prevent the water from oozing through the joints. It then riſes through a perpendicular brick chimney to the height of the mill lead, by its preſſure in the high ground.

The advantages of ſuch operations muſt be very great in many ſituations, and may often be accompliſhed with ſucceſs where many would think them impracticable.

Of the practicability of this, however, and that water may often be raiſed to a very conſiderable height by means of its preſſure in diſtant ground, the following remarkable occurrence, which happened lately in digging a well in the vicinity of London, is a proof: Earl Spencer, for the preſervation of his noble manſion houſe at Wimbledon againſt fire, and to be well ſupplied with water, ordered a well to be dug at a little diſtance from the houſe, which was ſunk to the amazing depth of near ſix hundred feet before any ſpring was found. It was begun on the 31ſt of May 1795; and, on the 12th of Auguſt 1796, the man who was employed in the undertaking gave a ſignal to the perſon above to draw him up, as he had found the ſpring, and was immerſed in water ſo deep that his life became endangered. In the ſpace of four hours, the water roſe to the height of three hundred and fifty feet, and, during two days following, its increaſe was more than a foot an hour. The water, proceeding from a rock, is remarkably fine, and from the ſtra-

ta it paſſes through, is ſtrongly impregnated with mineralic qualities. The ſinking of this well alone has coſt his Lordſhip about two thouſand pounds, but will recompenſe him by its utility; as, before it was done, the only ſupply for the family, was either rain falling during the wet weather, or water procured from the adjoining fiſh ponds. As there is no extent of higher ground near that where the well is ſunk, and as the depth of it is ſome hundred feet below the bottom of the Thames, the ſource of the reſervoir from whence the ſpring is ſupplied muſt be ſituated at a very great diſtance, and muſt contain a very large body of water to raiſe it ſo ſuddenly to ſuch a height.

CHAPTER V.

Drainage of Bogs and other Wet Ground, by perforating through a Retentive to a Porous Subſtratum.

In many parts of the country, conſiderable tracts of land lie waſte and uncultivated, owing to wetneſs in a particular ſituation, that might by this means be eaſily drained, and rendered much more productive. The cauſe of their wetneſs proceeds, not from ſprings lying either under the ſurface, nor from the overflowings of any in the adjoining higher grounds; but from the accumulation of rain water, ſtagnating on a retentive body of clay or other impervious ſubſtance, through which the water can have no deſcent; and being alſo ſurrounded with higher ground of the ſame impervious nature, the water of itſelf can have no natural outlet. Such ground, when it becomes boggy, is commonly called *LANDLOCKED BOGS*. The ſituation of theſe bogs, being often ſo much lower than the ground that ſurrounds them, the cutting of a main drain, or conductor, for carrying off the water collected by the ſmaller drains, would, in many caſes, be attended with an expence greater than the value of ſuch land when drained. The thickneſs of the impervious ſtratum that

retains and upholds the water, is often ſo great, that, although the ſtrata under it be of a porous and open nature, as rock, ſand, or gravel, the water can find no paſſage whereby of itſelf to deſcend through the one into the other, and therefore, by its long ſtagnation above, all the coarſe vegetables that have for a ſeries of years been produced on its ſurface, and even the upper part of the ſoil itſelf, are formed into a body of peat-earth, equally ſoft, and leſs productive, than that of any ſpring bog, and which is only paſſable by cattle in very dry ſeaſons, when the wind and ſun exhale part of its moiſture; but is even then inacceſſible to the plough.

THE drainage of theſe bogs muſt be effected in a manner different from that of ſpring bogs, the cauſe of both not being the ſame. In the following manner it may be done at leaſt expence. The firſt drain muſt be made in the middle or loweſt part of the ground, and into this all the others muſt lead. The number and direction of theſe muſt depend on its extent. They muſt be cut through the peat, or wet ſpongy upper ſoil, to the top of the clay or retentive ſubſtratum, which muſt be perforated by the auger, in order to give an *OUTLET DOWNWARDS* for the water, which will be abſorbed by the porous ſtrata below *.

* MAKING one large pit or well in the middle or loweſt part of the bog, dug through into the porous ſubſtrata, with the drains leading into it, would anſwer equally well, and would ſave boring along each of the drains. " If a pit is ſunk twen-

The drains ſhould be cut as narrow as poſſible, and, after the auger-holes have been made, ſhould be filled with looſe ſtones to within a foot and a half of the ſurface; and this vacuity may be filled up with part of the earth taken out, having a turf, graſs ſide downwards, next the ſtones. The water and noxious moiſture contained in the peat or upper ſoil will be extracted by the drains, and will ſubſide through the auger-holes.

" ty or thirty feet deep, in the middle of a field through the Hertfordſhire red, " flinty, and impervious clay, into the chalk below, when the uſual quantity of " chalk is taken out, the pit ſhaft is filled up with the flints taken out of the chalk " and clay, and the top drainage of this part of the field much ſhortened for " ever afterwards, by making principal drains from the part of the field above the " level of the top of the pit terminate therein, and the ſuperabundant moiſture will " eſcape through the flints in the pit ſhaft to the chalk below. And if a drain is " carried into a limeſtone quarry, it is ſeldom neceſſary to carry it farther.

" In dells or hollows of conſiderable extent, covered with an impervious ſtra- " tum, and from which there is no natural drainage, ſuch as the valley between " Mold, the ſhire town of Flintſhire, and the adjoining high land, a pit about four " feet diameter, and fifteen feet deep, more or leſs, as the caſe may require, is ſunk " through the impervious ſuperſtratum into a pervious ſtratum of gravel, and the " rain water and of ſome adjoining ſprings are carried from the ſurface thereby: the " pit is railed round, to prevent cattle from falling into it. I muſt here remark, that " though in this, as well as in many other inſtances that may be given, the top wa- " ter eſcaped through the pervious ſubſtratum, the effect might have been direct- " ly the contrary. I therefore recommend the impervious ſuperſtratum, in all " ſuch caſes, to be perforated by bore-rods, and the hole made by them is eaſily " ſtopped up." *Agricultural Report of Hertfordſhire*, page 66.

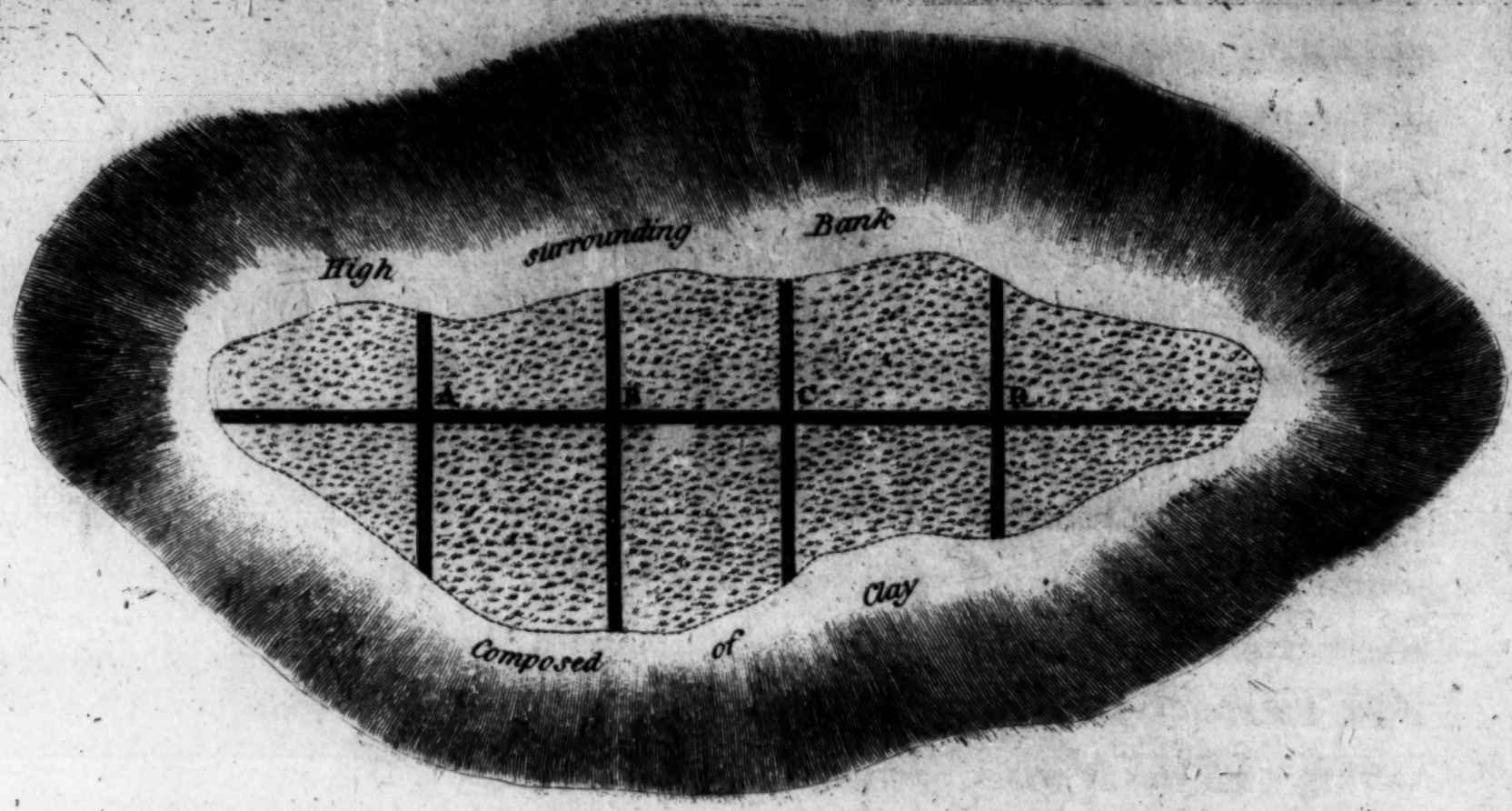
If the ground is afterwards ploughed, care muſt be taken in forming the ridges, and giving them a proper deſcent towards the main drain, which will greatly aſſiſt the others in diſcharging any heavy falls of rain water. The obſervations in the annexed note from the Roxburghſhire Report may be uſeful in this reſpect, as well as to the future improvement of the ground.

BEFORE proceeding to drain this land in the manner deſcribed, the following obſervation muſt be attended to: It ſhould be diſcovered, in the firſt place, whether the porous ſtrata immediately under the clay is dry, and will receive the water when let down into it from above, or being already ſaturated with water itſelf, may, in place of receiving more, throw up a greater quantity to the ſurface; and thus, inſtead of remedying the evil, render it worſe. This may ſometimes be the caſe, and the ſubſtrata may contain water that makes no appearance on the ſurface *AT THIS PLACE*, owing to the ſuperincumbent body of clay, but which, being connected with ſome higher ſpring, may flow up when a vent is given to it by the auger. Thus would a greater quantity of water be brought to the ſurface, which, having no outlet through the circumjacent bank, would render the ground much more wet, and might even, in ſome ſituations, almoſt form a lake. If the ſurrounding high ground declines deeper or lower than the bog, although at ſome diſtance, by means of a ſpirit-level and the appearance of the ſurface, the nature of the under ſtrata may, in a certain meaſure,

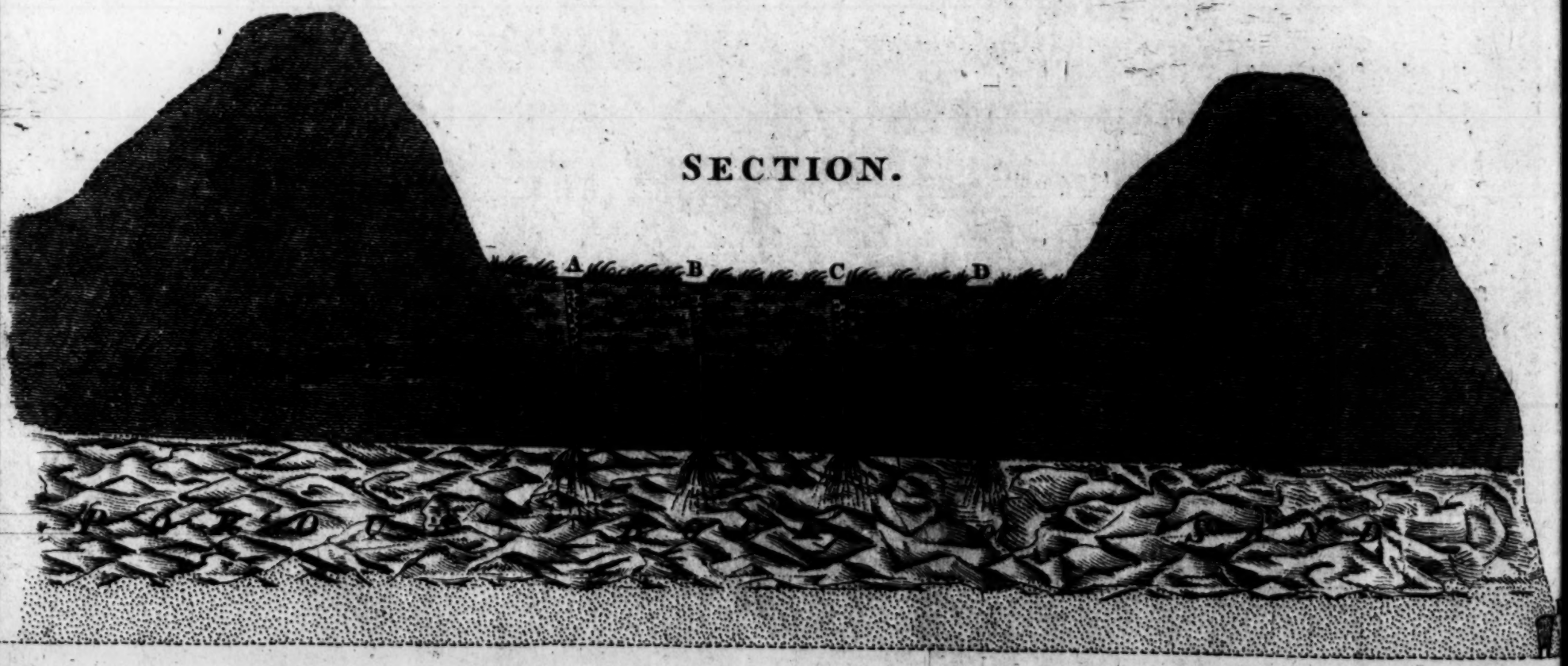

G.R. III

PLAN *representing the Drainage of a* **Bog** *or piece of Marshy Ground by perforating through an impervious to a porous sub stratum.*

N°. 7.



SECTION.



The letters **A.B.C.D.** *in the Section correspond to those in the Surface View, and represent the Drains cut thro' the Peat earth & filled up with loose Stones to within a foot & half of the top* **E.F.G.H.** *represent the perforation of the Clay by the Auger holes, and the descent of the water into the Rock below*

J. Johnston del.

Neele sculp. Strand

be diſcovered; and although it ſhould already contain water, a drain can be there cut to draw off that water, and alſo what is let down into it from above. See letter K in the ſection of Plan, No. 7., which will help to elucidate theſe remarks.

THE following extract from Dr. Nugent's Travels through Germany in 1766, will ſhow the mode of draining marſhes in that country, nearly on the ſame principles as explained in this chapter:

"THE draining of marſhes is conducted in much the ſame manner as that of lakes; but here I have ſeen the operation performed only on what we call moor or turf grounds.

"THESE are moſt eaſily drained by carrying trenches through thoſe grounds, when the diſpoſition of the country is ſuch, that the water can be conveyed to ſome neighbouring ſtream.

"THE firſt thing they do is to carry a ditch to the middle of the moor in a direct line, its depth and breadth adapted to the extent and wetneſs of the ground; and thus to the ſuppoſed quantity which is to be carried off. Every ſix, eight, or ten perches, as the ground is more or leſs ſwampy, croſs trenches on both ſides are drawn in a direct line, and communicating on both ſides with the main trench. But, in caſe of water coming from any neighbouring eminences, they dig a trench round

the whole ground as a reſervoir; and this likewiſe communicates with the main trench, &c.

"In caſe the draining of the water into ſome natural receptacle be not practicable, at leaſt not under a very great expence, then they have recourſe to ſinking ponds or reſervoirs in ſome neighbouring bottom, and to theſe they carry all the trenches.

"These ponds are likewiſe of uſe as a fiſhery; but, if even the ſinking of ſuch a pond be too chargeable, there ſtill remains an expedient which is of good effect, and chiefly if the moors are not too wet and marſhy.

"It is the nature of moors in general, that, beneath the turf or moſs, there is a loam which hinders the moiſture from penetrating; and this indeed is what makes the marſh, and cauſes the luxuriant growth of the turf or moſs; but this loam or clay is only a ſtratum, and far from being of an immenſe depth; under it is generally a ſand, or ſome other ſtony or looſe ſoil.

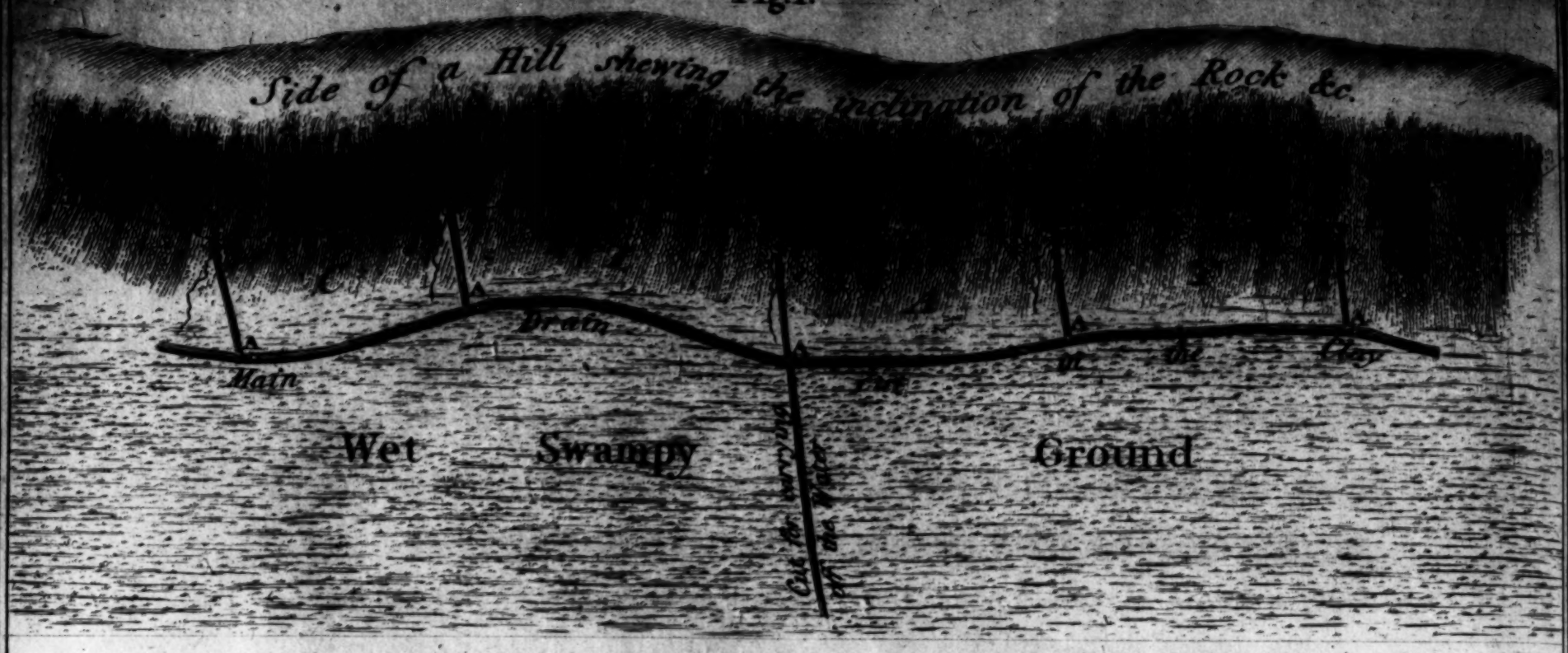
"Here reaſon readily informs us, that a middling moraſs may be drained by *PERFORATING THE CLAY*, and thus make way for the moiſture to penetrate. In order to this, a pit is dug in the deepeſt part of the moor, till they come below the obſtructing clay,

G.R. III.
BRITISH MUSEUM

PLAN N.º 4.

Fig.1st

Side of a Hill shewing the inclination of the Rock &c.



SECTION OF A HILL

Fig.2nd

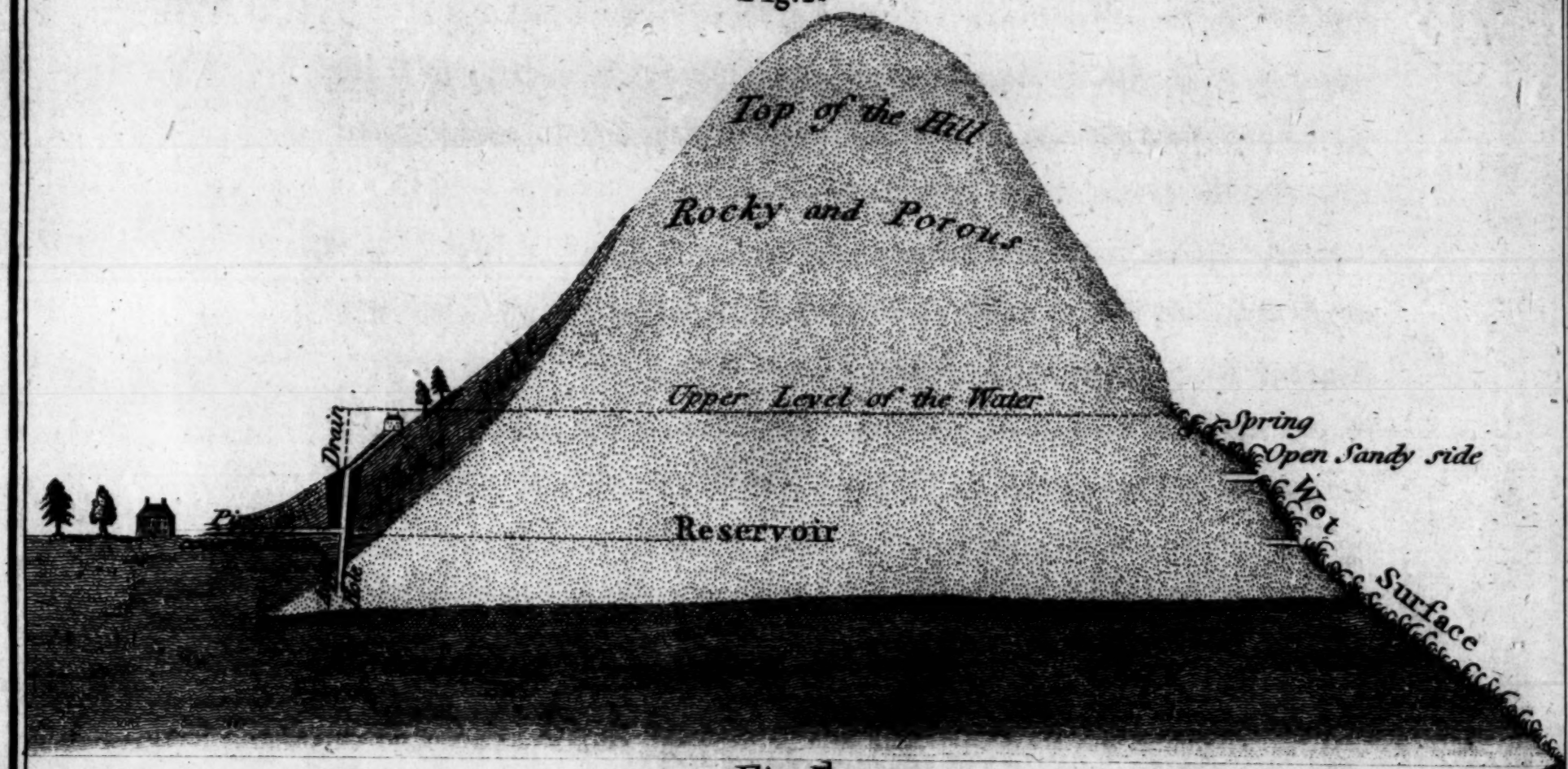
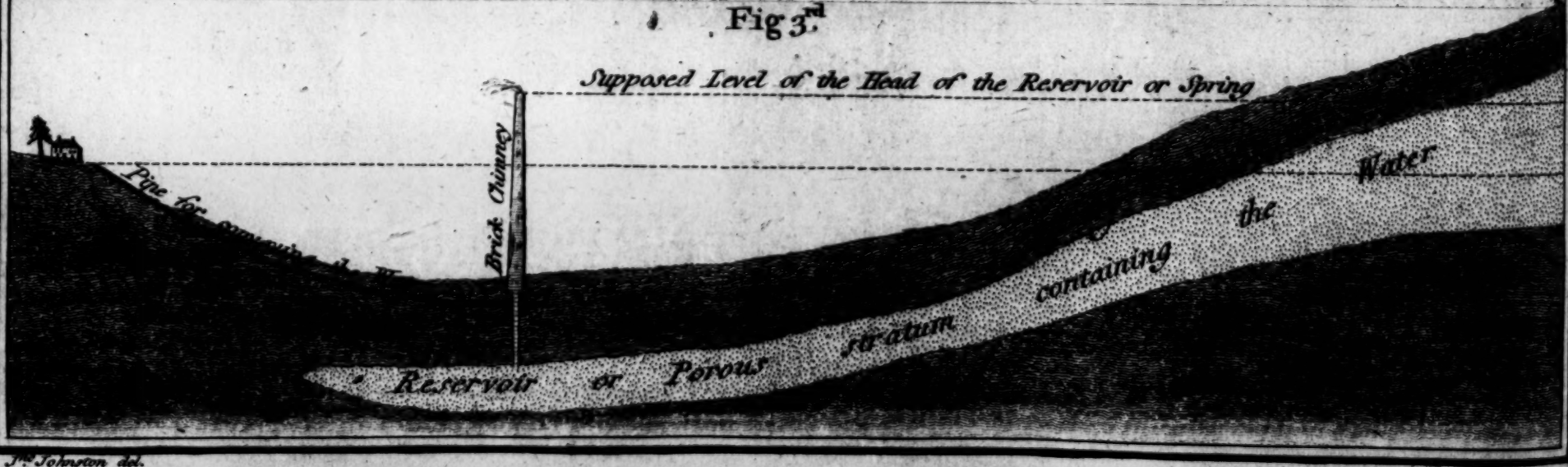


Fig 3rd



Js. Johnston del.

Neele sc. Strand.

and meet with ſuch a ſpongy ſtratum as, in all appearance, will be ſufficient to imbibe the moiſture of the marſh above it. Into this pit the ebbing of the moraſs is conveyed through a trench, and both the trench and the pit are filled up after the firſt drain with large broad ſtones, ſetting them edgewiſe, ſo as to leave interſtices for carrying off the water: then ſuch ſtones are laid over breadthwiſe, and theſe covered with looſe earth, like that on the ſurface. When no ſuch ſtones are to be had, ſtrong piles are rammed down the ſides of the trench, and broad boards laid acroſs: and theſe are covered with earth to a height fit for culture.

"THIS is a matter of no great expence, the pit being as near the moraſs as the water will admit, and the trenches but ſhort: then they have a drain unperceived, which leaves the ſurface of the trenches for the plough; and in middling marſhes, eſpecially in ſuch moors as are only wet and damp, this method, though ſometimes ſlow, never fails taking effect; and many tracts are thereby made ſerviceable to the farmer or grazier."

MR. MORICE has drained a field of fifty acres in the neighbourhood of Aberdeen, exactly in the manner deſcribed by Dr. Nugent, from whoſe publication he took the hint.

The following Extract from the Roxburghshire Report, explains a similar Practice which had been successfully attempted in that part of the Kingdom.

"In the first place, it will be necessary to premise, that from one to six feet deep, below the surface of the waste lands that might be made arable in this county, is found a large seam of a black slaty, or metallic substance, generally from twenty to twenty-five feet in thickness; and below this is found a mass of whinstone rock, both laying in a tolerable regular straight line. The thickness of the whinstone rock, I presume, is unknown, as I have not heard it was ever bored into. The black slaty, or metallic substance, is generally found so closely cemented, as it were, without chinks, or fissures, that it is impenetrable even to water, or any other liquid; while, on the contrary, the whinstone rock, when come at, abounds with chinks and fissures, and will receive and swallow up any quantity of water poured into its bosom. The surface of the earth, above the slaty, or metallic substance, is found every where of a light, kernelly, and mossy nature, apparently having, in the course of a series of ages, been produced and formed from the vegetable substances which had attached themselves to it: falling in the autumn seasons, and having no receptacle to receive the rain water as it falls below its stratum, it preserves it on its surface, and in the winter months becomes swelled and enlarged in a

conſiderable degree. In the ſpring months, when the ſun and wind abſorbs it, and cauſes it to exhale, it becomes of a tolerable firmneſs, and produces a coarſe kind of unprofitable graſs, mixt in many places with ſhort heather, of no uſe either for the rearing or feeding of ſheep or cattle.

"HAVING in a brief manner given you an account of the ſeveral ſtrata of which the waſte lands of this county is compoſed, which every perſon in the habit of improving, ſhould be well acquainted with, and have, as it were, conſtantly in view, I ſhall now proceed to give an example or two of the method of cultivation I took, and then add a few obſervations.—In the year 1784, after I had ſowed up my fallow quarter on old land with wheat, and the autumn proving pretty dry, I, in the latter part of October, ploughed up twenty acres of waſte lands, of the above deſcription, and as one part of it lay nearly on a level, and the other on the ſlope of a hill, I divided it into two parts, judging it might be neceſſary to cauſe each part to undergo a different courſe of cultivation. The level part I gathered up in ſmall ridges, and ploughed it pretty deep, making the furrows narrow, keeping two labourers following each plough, as well to remove any obſtructions that might ariſe from ſtones or roots, as alſo to turn the upper rim, or ſurface below, when the plough was the fault. This done, I allowed it to lay until midſummer 1785. But in the ſpring months, ſoon as it would bear my ſheep and cattle, I drove them up and down the

ground as often as occaſion would permit, as well to nip off any ſprouts of graſs that might appear, as to tread it to a firm conſiſtence, and which was attended with moſt beneficial effects. At midſummer, having no other fallow that year, I gathered it up again, but finding, although the ridges were getting high, being only ſet out eight feet at firſt, the plough did not get to the ſlaty ſubſtance in the hollow of the ridge, I was obliged to lay out the ridges ſixteen feet:—this coſt me a deal of trouble; but I eventually got the plough down to the ſlaty ſubſtance. When my work was done ſo far, my next thoughts were directed to get the water drawn out of the hollow of the ridges, being at leaſt four feet below any level I could obtain. To remedy this, I got a pair of bore rods, which I put down the ſlaty ſubſtance, to the whinſtone rock, at ſundry places, and which effectually anſwered my purpoſe, keeping the tops of the holes or canals covered with a baſket of looſe ſtones, which I allowed to remain, or remove at pleaſure, as the weather proved more or leſs wet.

"In the ſpring of 1786, I had the pleaſure to find my waſte land was in a condition to ſow, as early almoſt as any other part of my farm: the winter rains falling through the ſoil upon the ridges into the boſom of the ſlaty ſubſtance, which was laid bare in many places, in the hollow of the ridges, it was gently drawn off, and glided regularly into my canals. In the ſpring of 1786, I ſowed in drills my firſt crop, of Dutch oats, without

any dreſſing, running the drills over with a light roller, to preſs the earth, and prevent the drought taking hold of, and penetrating to the plants, which was of great uſe: and in the beginning of September, I had the pleaſure of reaping a tolerable good crop, of about five bolls per acre; but the quality, as might be expected, was coarſe, the ſtems growing to a great ſize, which aroſe from my not giving the drills a ſufficiency of ſeed.

"In the ſpring of 1787, I gave it two ploughings, and a ſlight dreſſing of dung, marl, &c. compounded together, and ſowed my ſecond crop in drills again, conſiſting of Haſtings peaſe; theſe I ſowed pretty thick, and produced a fine crop indeed. In ſpring 1788, I ſowed Dutch oats again, in drills as before, which turned out well, both with reſpect to quantity and quality, and continued to grow the ſame crops in ſucceſſion until 1792, that I left the farm.

"I ploughed, on the contrary, the other part of the waſte ground on the ſlope of a hill, in thin broad furrows, uſing the ſame meaſures and precautions as above deſcribed, and which I allowed to remain until the midſummer of 1785 alſo, when I ſet a ſtrong brake to work upon it, hoping to tear its upper ſurface to pieces, and thereby ſave me a ploughing; but I found myſelf miſtaken in this, for the ſurface not being ſufficiently covered with earth, had not experienced an alteration ſuffi-

cient to yield to the experiment; I was therefore neceſſitated to prepare it for burning; but the weather proving wet at the end of the ſummer, rather foiled me, and obliged me to give up any farther progreſs for the ſeaſon, and leave it in a more backward ſtate than the part firſt mentioned.

"In the ſpring of 1786, I gave it two ploughings, braking, &c. but it ſtill proving large and lumpy on the ſurface, for the reaſons before aſſigned, and deſpairing of its growing any thing, I at laſt, after much deliberation, determined to ſow it in drills with peaſe, giving it a large quantity of ſeed, not with a view of a crop, ſo much as covering the ſurface cloſe with the plants, and thereby accelerate its cultivation. The number of plants puſhing forward at the ſame time, for want of air at the roots, greatly weakened one another, and proving in the end of a dwarf kind, produced me a good crop, at the ſame time that they improved the lands in the way I expected. In 1787, I ſowed Dutch oats, in the way and form before deſcribed, changing the ſeed yearly, until I left the farm, as mentioned before.

"As the ſoil above the ſlaty ſubſtance was not above two feet and an half deep, the plan of ſetting off the ridges eight feet broad in this part of the land, anſwered well.

"Being ſatisfied, from many experiments and obſervations, of which the above caſes will bear me through, that the waſte lands

in the kingdom ariſes from the firſt ſolid ſubſtance found under the ſurface, being impervious and impenetrable to rain, or any other liquid body, as before explained; and as theſe ſolid ſubſtances lie pretty near the ſurface, all attempts to improve waſte lands will be fruitleſs, unleſs the ridges are laid off in breadth proportionable to the depth of the ſoil, ſo as to allow the plough to get to theſe ſolid ſubſtances in the hollow of the ridges; that done, waſte lands ſoon prove prolific and valuable. Exceſs of heat and cold have the ſame effect on vegetation: thus in hot ſultry ſummers, we ſay vegetation is at a ſtand, being quite burnt up; and in cold wet ſummers, we ſay vegetation is at a ſtand, being ſcalded, and hurt by the wet. The firſt we can only guard againſt, by ſowing early: the other we can overcome by draining, &c. which no farmer ſhould omit."

CHAPTER VI.

Drainage of Soils compoſed of alternate Beds of Clay and Sand.

In diſtricts where the ſoil is compoſed of an intermixed variety, and where clay forms the moſt predominant part, draining is a work attended with much greater difficulty and expence than in thoſe where both the ſurface and internal ſtrata are more regularly diſpoſed. In theſe kinds of ſoils, where every reſervoir of water is unconnected with another, being ſeparated by intervening beds of clay, the partial collections of water that theſe reſervoirs contain are ſo much augmented in time of great rains, that, being full to the level of the ſurface of the ſurrounding clay, the water, having then a free iſſue, as over the edges of a diſh, ſo overflows and ſurcharges the ſurface of that clay, and renders it ſo wet and ſour, that its produce becomes every year more ſcanty, and the nature of the ſoil itſelf more barren. As theſe ſand beds have no communication with each other, it requires as many drains as they are in number to extract the water from each of them. From the neareſt and loweſt part of the field to be drained, a trench muſt be cut up to the higheſt or moſt diſtant ſand bank, in ſuch a direction as, if poſſible, to

hit on ſome of the intermediate ſand beds, and ſave the making a longer ſide cut, otherwiſe neceſſary; but, where this would give many awkward turnings to the main trench, would neceſſarily lengthen it, and where, by croſſing the beds in places higher than the ſurface of the ſurrounding clay, would conſiderably increaſe the depth of it, and be difficult to work, eſpecially if rock or running ſand; drains in the form of letter Y muſt branch off to ſuch beds, to draw off the water they contain, and to convey it into the leading one, as repreſented in Plan 8. Fig. 1.

ALTHOUGH the ſand beds throw out the water they contain on all ſides, ſo as to injure the clay ſurface immediately round them, a drain on the one ſide will completely extract the water from the whole, and prevent it from breaking out at either ſide, provided that where it is cut be the loweſt.

IT may be obſerved, that, unleſs the drain is ſo cut, it cannot be ſuppoſed to have this effect, while the water can find an outlet on the oppoſite ſide of the bank lower than the bottom of the drain. This ought therefore to be previouſly conſidered; and, by carefully examining the ground, and applying the ſpirit-level, the proper ſide for the drain may eaſily be found. Or, if the water burſting out round the bank has been obſerved in dry ſeaſons to run at one place, and not at the others, it is a proof that this is the loweſt point, and, by cutting the drain

PLAN 8[a]

Fig.1[b]

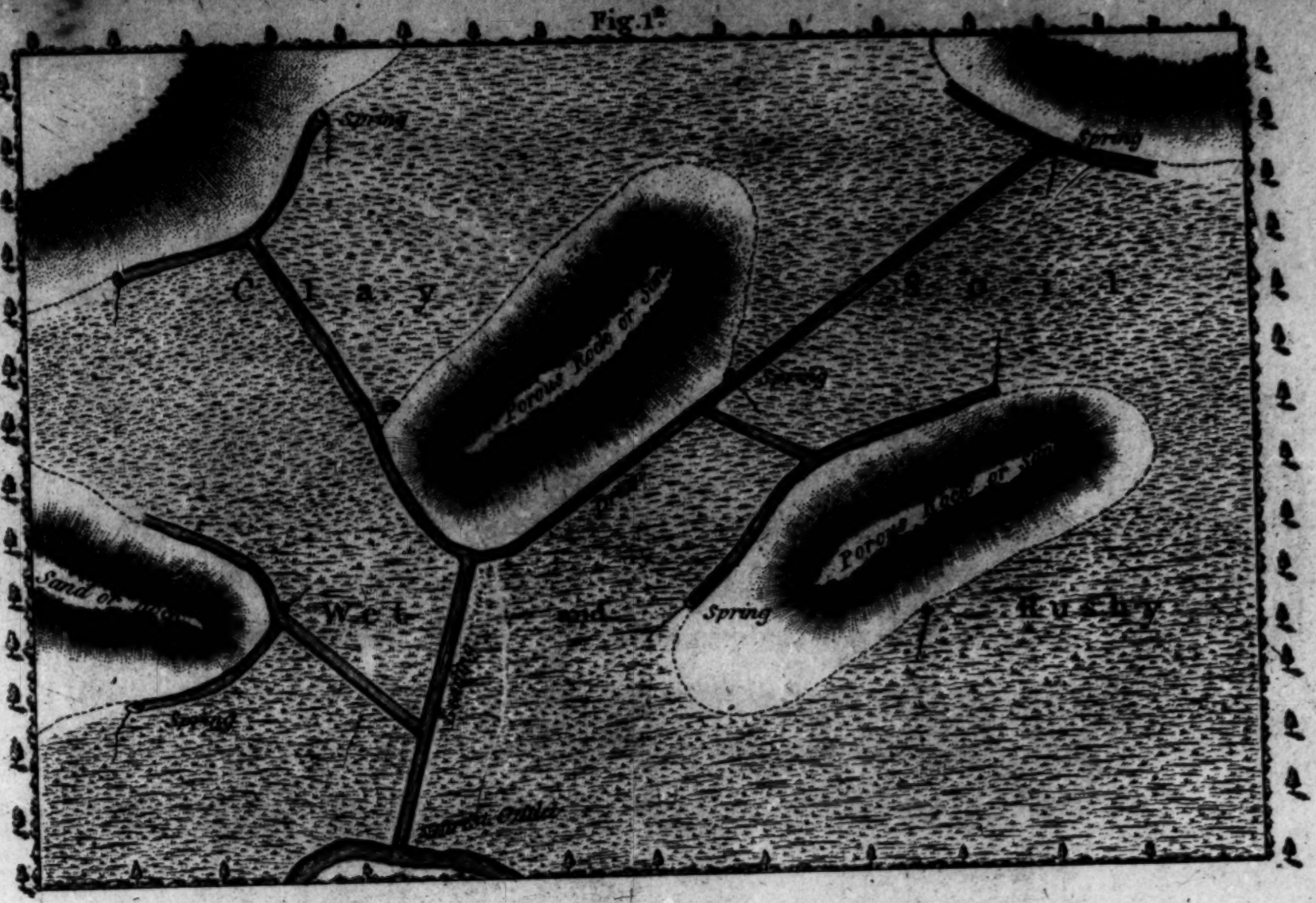


Fig.2[d]

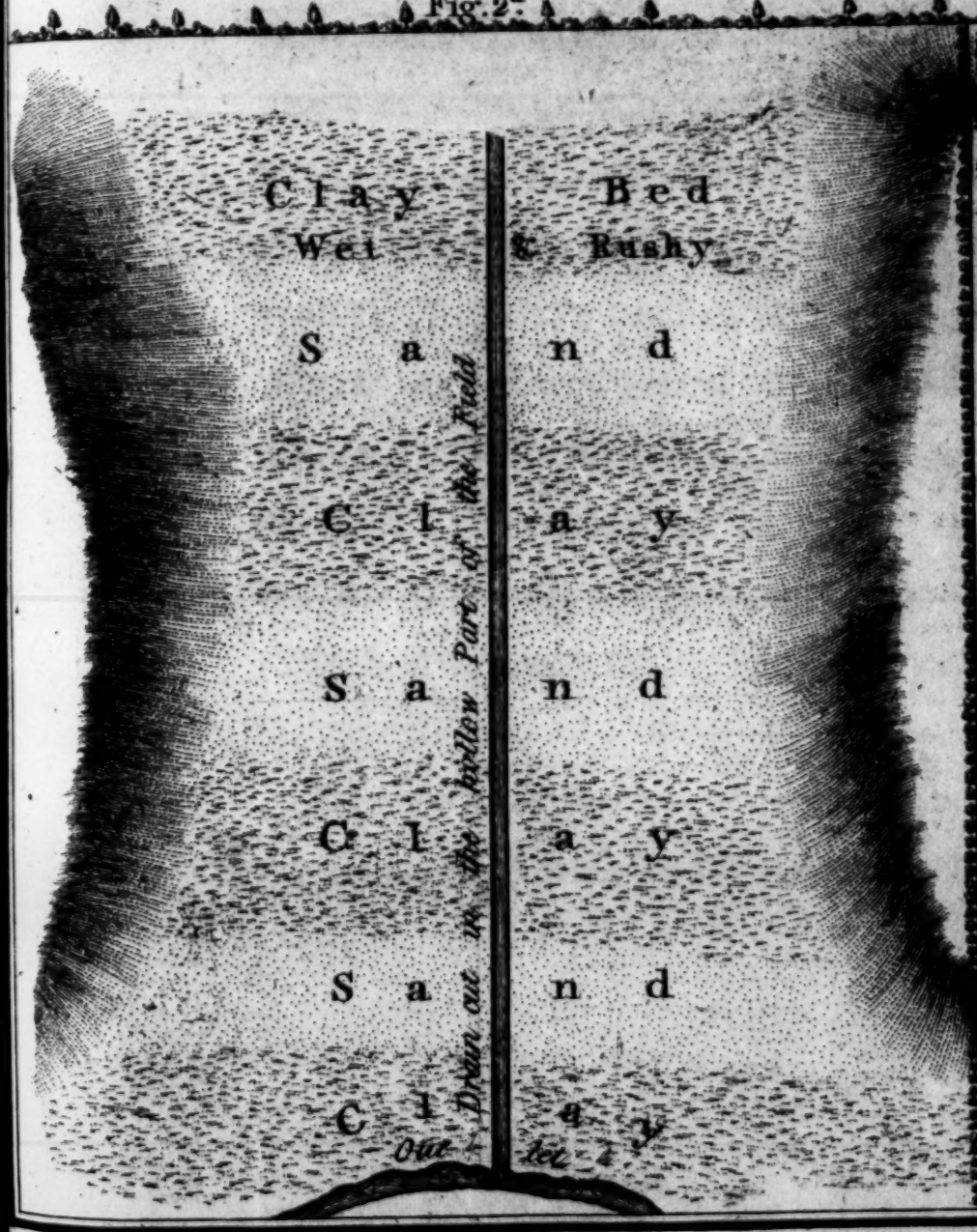
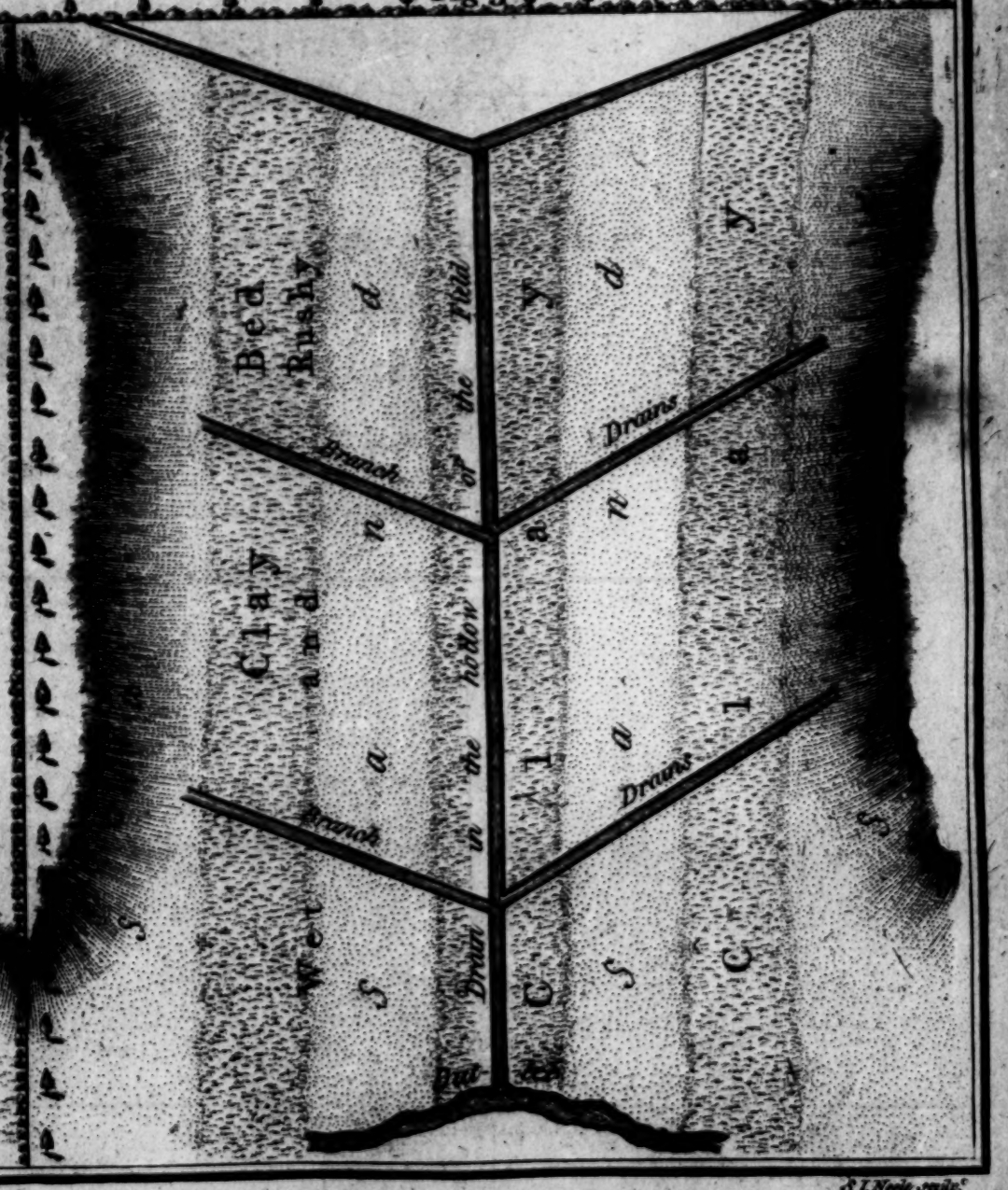


Fig.3[d]



J. Johnston del.[e]

R. I. Neale sculp.[t]



in the direction of this level, the water will afterwards be prevented from riſing to the height of the upper outlets, or above the level of the bottom of the drain, even in the wetteſt ſeaſons.

BESIDES ſoils correſponding to this deſcription, there are others nearly of a ſimilar nature, but each bed being of leſs extent, and lying more regularly together, their drainage can be more eaſily effected by means of leſs cutting, and conſequently leſs expence. Under the beds of ſand and clay that thus lie alternately together, and almoſt parallel to one another, is found a body of impervious clay that keeps up the water contained in the ſand, which continues always full, moiſtening the adjacent clay, and, in wet ſeaſons, running over it. As the *MAIN UNDER STRATUM OF CLAY* is ſeldom above four or five feet below the ſurface, a drain muſt be cut to that depth through the middle of the field, if it has a deſcent from both ſides; or, if the ground declines all to one ſide, the drain muſt be cut there, where the water will more eaſily diſcharge itſelf into it; and, unleſs the field is of conſiderable extent, and have more hollows in it than one, one drain will anſwer the purpoſe effectually; for, by croſſing all the different beds that hold the water, it will draw it from each. See Fig. 2.

THE great difficulty, however, in draining land of this deſcription, and which is impracticable by one drain, is, if the

direction of the alternate beds of clay and ſand lie *ACROSS THE DECLIVITY* of the grounds; ſo that one drain in this caſe can have no other effect than that of carrying off the water after it has paſſed over the different ſtrata, and would here naturally ſtagnate in the loweſt part of the field, if there was no other outlet for it. Therefore, when the ground lies in this manner, which is often the caſe, beſides the drain in the hollow, others muſt be cut up from it, in a ſloping direction, *ACROSS THE DECLIVITY*, which, by croſſing all the different veins * of ſand, will extract the water from each. See Fig. 3.

WHERE theſe alternate ſtrata are of greater extent, and the wetneſs produced by greater ſprings, forming ſwamps at different levels on the ſides of hills, the method of draining them has been deſcribed in Chapter IV.

THE firſt thing to be obſerved, in the drainage of ſuch alternate ſoils, is to diſcover minutely the inclination of the alternate ſtrata, or how they lie with regard to the ſituation of the field to be drained, as upon this the direction of the drains entirely depends; and as the external ſigns that diſtinguiſh the different beds, are eaſily perceptible from the appearance of the ſurface, and difference of the herbage that each produces, there is little difficulty in attaining this part of the object. In drains of this

* A very thin or narrow ſtratum.

kind, there is ſeldom any need for applying the auger, as the neceſſary depth of the trench reaches far enough down, and as there is no ſpring for want of connection with higher ground, to force itſelf up through the auger-holes, or, if there is, it cannot, at ſo great a depth, and below ſuch a body of clay, do any injury to the ground above.

THE drain, after being formed like a *SOUGH* at bottom, or ſet like a triangle, muſt be filled a conſiderable way up with ſmall ſtones before the mould is thrown in, taking care to have *TOUGH SODS* laid immediately above the former. Where ſtones are ſcarce, and plenty of bruſhwood at hand, faggots may be ſubſtituted in their place with propriety. The under part of the drain, however, ſhould be laid or *COUPLED* with ſtones, as a canal to carry off the water ſubſiding through the faggots, and which has alſo the good effect of prolonging their duration; for when the water cannot get clearly off, which muſt be the caſe where there is no open conduit of ſtones, its ſtagnation amongſt the branches muſt ſoon cauſe their decay, and choke up the paſſage of the drain. There is one thing more to be attended to, in completely accompliſhing the drainage of theſe ſoils: If the field lies very much on the deſcent, care muſt be taken in laying out the *BRANCH DRAINS* in a direction ſufficiently horizontal, ſo as not to make the fall too precipitant, by which the bottom of the trenches would be worn uneven, and thus would obſtruct the paſſage of the water, which might ſoon

blow them up; but the fall ſhould be ſuch as to enable the water to clear its courſe. The reaſon why fewer drains are required in fields that lie nearly horizontal (as thoſe of the 2d claſs in this Chapter), is, that the water is drawn equally from both ſides; whereas thoſe on a ſloping declivity, drawing only from the higher ſide of the drains, require them to be more in number, or cloſer to one another. This is the caſe in every ſituation where ſurface draining is neceſſary, and particularly ſo in ſuch ſoils as thoſe deſcribed in Chapter VII.

In Lancaſhire, where theſe ſoils compoſed of alternate beds of clay and ſand very much predominate, and which have there acquired the names of *SAND POTS OR GUTS*, (a term properly enough applied to them, from their holding water like a pot), Mr. Elkington has executed ſeveral drainages in the manner I have deſcribed; and alſo a very difficult one of the ſame kind at Suttonhall in Derbyſhire, where the water was contained in ſmall beds of rock, croſſed and intercepted by beds of clay; and to this Fig. 1. in the annexed Plan, No. 8. more particularly alludes.

CHAPTER VII.

Drainage of Soils Porous above and Retentive below, &c.

In flat tracts of land, where the ſurface or upper ſoil is injured by a ſuperfluity of ſtagnant water not proceeding from ſprings, their drainage is an object of the firſt importance, and which may, in moſt caſes, be accompliſhed with very little expence.

The upper ſoil being compoſed of a porous ſtratum of two, three, or four feet in thickneſs, and having under this a ſtrong retentive body of clay; the rain water falling on the ſurface, eaſily ſubſides till it meet the clay, and there being obſtructed from farther deſcent, the whole open part of the ſoil ſtands ſo full of water, as to retard the progreſs of vegetation, or at leaſt greatly to injure it *. To carry off this water, requires only one or few more drains, according to the ſituation of the field, and theſe no deeper than juſt to reach a few inches into the clay, betwixt which and the under part of the porous ſoil the greateſt quantity of water will remain ſtagnant, when it does

* This kind of ſoil is commonly denominated *WET-BOTTOMED LAND*.

not appear ſo much on the ſurface. In this kind of drainage there is no need for the auger, there being no *REAL SPRING* or ſubterraneous water to get rid of.

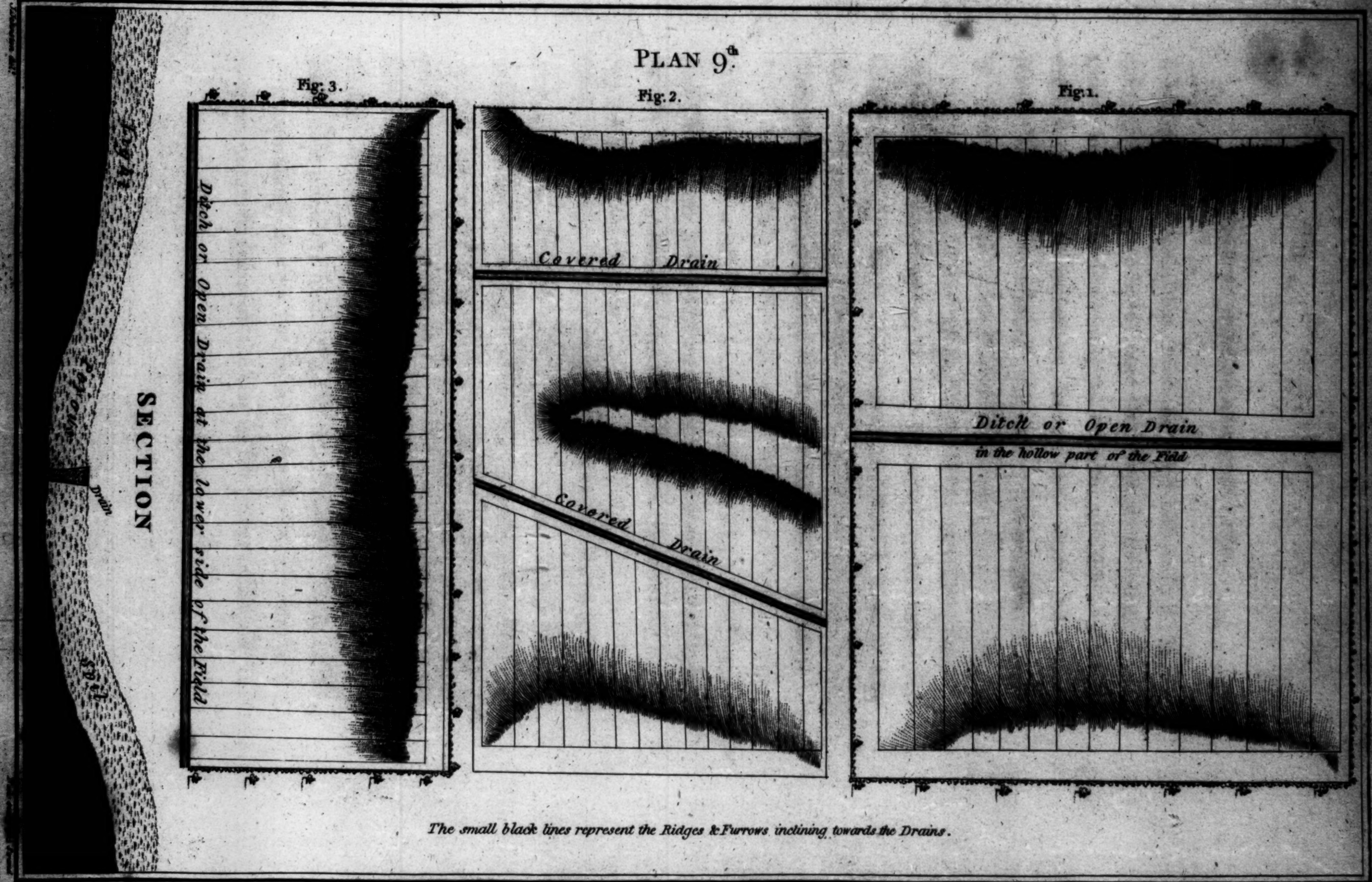
If it has a ſmall deſcent from both ſides, one drain cut through the porous to the clay ſoil, in the hollow part of the field, will effectually draw off all the water that the porous ſoil may contain, which will be greatly facilitated by properly forming the ridges to anſwer the declivity of the ground, and by deepening and clearing out the furrows with the ſpade. See Plan 9. Fig. 1.

If the ſituation of the field correſpond with the repreſentation of it in the plan, the water will flow into the drain (being in the hollow part of it) through the porous ſtrata, as well as through a number of ſmall trenches cut up from it to both ſides, which is the common practice in Eſſex * and ſome other counties adjoining; but it is cutting up a whole field to no uſeful purpoſe.

The drain may either be open, if it can ſerve as a diviſion of the field at the ſame time, or covered, as circumſtances may require.

* From its being ſo much practiſed there, this mode of draining is commonly called *THE ESSEX MODE OF HOLLOW DRAINING.*

PLAN 9th.



The small black lines represent the Ridges & Furrows inclining towards the Drains.

G.R.M.
BRITISH MUSEUM

If a field of this ſoil has more than one hollow in it, in that caſe it is neceſſary to have more than one drain; but, if it is almoſt level, or inclines only a little to one ſide, a ditch or drain at the loweſt extremity, having the ridges and furrows formed as already mentioned, will anſwer the purpoſe effectually. See Fig. 2. and 3. of Plan 9.

In ſome caſes, however, it may be neceſſary to have a few ſide cuts from the main drain, where the field is large or very flat, cut down alſo a little into the clay, as narrow as it is poſſible to dig them, and filled with ſtone in the uſual manner.

Such is the method of draining theſe ſoils with moſt advantage; but many fields ſuffer equally from wetneſs, that conſiſt of ſoil exactly oppoſite to the former, viz. a *CLAY SURFACE* having a *POROUS SUBSTRATUM*.

The drainage of ſuch ground, where the wetneſs is ſtill of a more injurious nature, and where the impervious ſtratum that upholds the water is of ſuch a thickneſs as to require being perforated by the auger, is fully deſcribed in Chap. V.; but here the depth of the drain being ſufficient to reach the porous ſubſoil, without the help of boring, the deſcription of ſuch may with more propriety form a part of this chapter. Fields of this kind commonly lie very flat, without any declivity, whereby the noxious water, ſtagnant on the clay ſurface, might naturally diſ-

charge itſelf without the help of drains; for ſoils of the ſame nature, in a hanging ſituation, are ſeldom or never affected by the ſame cauſe.

Such ground is more difficult to drain, and requires a greater number of cuts than any other ſoil whatever, as they muſt be ſo laid out and conducted, as to collect all the water from the ſurface, which can only diſcharge itſelf into the drains *FROM ABOVE*, being unable to flow into them through the clay, as in thoſe ſoils of an oppoſite deſcription; and where there is any irregularity on the ground, the water will remain ſtanding in the hollows, within a few feet of the drain. The firſt thing is to make one main conductor in the loweſt part, or at one end of the field, to receive and carry off the water collected by the ſmaller collateral cuts, which it may be requiſite to make on each ſide of it. If it ſuits the ſituation or diviſion of the field, this main drain had better be open than covered, and then the outlets of the other drains that fall into it, can eaſily be inſpected, and frequently cleared out, as occaſion may require. The proper formation of the ridges, to anſwer the declivity of the ground, ſhould be particularly attended to in ſuch ſoils. The ridges ſhould have riſe enough in the middle, to give the water a fall into the furrows, and theſe ſhould have depth and fall enough to convey it into the drains. Thus would a great part of the rain water, as it falls, be carried off, which would leſſen the number of ſmall cuts otherwiſe neceſſary. The drains ſhould all be dug

as narrow as poſſible, and filled up in the uſual manner with looſe ſtones, only, the bottom of the conducting drain (if it is not an open one) ſhould be formed in the manner already deſcribed, with a ſmall open conduit at bottom, the more eaſily to carry off the water.

THE ſmall drains ſhould alſo be *COUPLED* at bottom, *i. e.* two of the largeſt ſtones laid in the bottom inclining on one another above, forming a triangular opening of four or ſix inches below. As the water is all received in at the top of theſe drains, it is neceſſary that they ſhould be filled with ſmall ſtones ſo near to the ſurface, as to leave only a ſpace to be filled with *LOOSE GRAVEL*, ſufficiently deep, to prevent the plough or harrow from deranging them. Looſe gravel, if it is at hand, is better than the ſtiff clay that came out of the drain, as it more eaſily admits the water to abſorb through it into the ſtones, and the other can be ſpread on any adjacent hollow in the field.

A THIN *LAYER* of ſtraw or ruſhes * ſhould be laid immediately above the ſtones, to prevent the ſmaller part of the gravel from filling up, too cloſely, the interſtices betwixt them; but this is not ſo requiſite when gravel is uſed in place of the *MOULD*. This mode of draining is calculated for every tenacious clay ſoil, whether porous below or not; but in many inſtances the deepen-

* If the field is in paſture, the *UPPER TURFS, PARED THINLY OFF*, will anſwer this purpoſe better than ſtraw or ruſhes.

ing of the furrows, with very few drains, might remedy the evil, where the *RETENTIVE UPPER SOIL* is only a foot or two deep, with a *POROUS SUBSOIL* under it, through which the water would eafily fubſide downwards, and again empty itſelf at ſome lower extremity of the field. The drains and furrows ſhould therefore be deepened through the clay to the open ſoil, in order to facilitate the deſcent of the water; and thus, much depends on the proper ploughing of ſuch ground, by attention to which, many drains, otherwiſe neceſſary, might be ſaved.

THE drainage of theſe ſoils does not come immediately under the ſyſtem of Mr. Elkington's practice; but the mode of treating them I have deſcribed, he recommends as the moſt effectual.

CHAPTER VIII.

Drainage of Mines, Quarries, Marl Pits, &c.

THE principles of Mr. Elkington's ſyſtem have hitherto been confined only to the draining of land, or taking away *SUBJACENT WATER* that injures its ſurface; but there is no doubt that it might be equally ſucceſsful, and of very material importance in the caſe of mines and quarries; by diminiſhing the quantity of water that is frequently found in the courſe of working them, and which very much obſtructs, and even ſometimes puts a ſtop to the work altogether; at leaſt it very often does ſo, in quarries of freeſtone, limeſtone, marl, &c.

THUS, from the want of Mr. Elkington's method being known, many mines and quarries at preſent lie unwrought, from the fear of water and quickſands, which might otherwiſe be wrought to advantage.

IT is well known that all ſprings and ſubterraneous collections of water are ſupplied from ground lying higher than that where they are found; which being of a porous nature, admits

the rain to filtrate through it, which deſcends often to a very great depth through the pores of the open ſoil, rock, ſand, gravel, &c. before it be obſtructed by ſome impenetrable ſtratum. Thus, in ſinking a pit for coal, or any other ſubterraneous mineral near the bottom of a hill or high ground, a bed of quick-ſand is met with, ſo full of water, that to paſs through it becomes a very difficult and expenſive operation; and as this water proceeds from the porous ground lying above it, it may in many caſes be practicable, to intercept the greater part of that water before it reach the ſand-bed in the pit, and by means of *TAPPING AT THE TAIL OF THE SAND-BANK* (provided the ground naturally declines lower than where the ſand is found in the pit), the whole of the water may be extracted from it, at a comparatively ſmall expence with what is uſed as the common remedy in like caſes.

To accompliſh this, in aſcending from the pit, carefully examine, if higher on the declivity, any bed of rock, ſand, or gravel *TAILS OUT*, which may convey the water contained in it to the ſand-bed below; and if ſuch bed is found, a drain may be cut into it, which will carry off a great part of the water, and conſequently leſſen the quantity in the mine, which would otherwiſe have continued to deſcend through the porous ſubſtrata, before being thus intercepted in its deſcent. But, although this is done, and the ſupply from above entirely cut off, yet a ſufficient quantity of water to injure the pit, may conti-

nue to ooze from the ſides of the ſand-bed, even ſuppoſing it ſhould *DIP* towards the lower ground, which, if it does, that water may be eaſily drawn off at ſome point in the low ground.

To effect this, in order to remove the above inconvenience, in deſcending from the pit, along the declivity, endeavour to diſcover at what place in the low ground the ſand terminates or *TAILS OUT*, which may be found by means of a ſpirit level; and if there is any appearance there of the water's having a natural outlet, it may, by means of a deep drain, be much quicker and more effectually drawn off; for ſprings naturally flow through narrow and crooked perforations, and conſequently, whenever the orifice is enlarged, or made lower, the diſcharge of water becomes greater: But, if there is a deep covering of clay above the tail of the ſand, in that caſe a drain can only be cut ſo far into it, and by means of boring through the remaining portion of clay, an eaſy outlet may be given to the whole water contained in the above ſand-bed.

THIS will alſo, in a great meaſure, remove, or at leaſt relieve the difficulty that would afterwards have attended ſinking the pit; for the water thus cut off, muſt leſſen the quantity that would have been found deeper, the ſame body perhaps paſſing downwards from ſtratum to ſtratum, ſo far as they continue porous, or capable of receiving it.

It is therefore of material conſequence to drain all ground lying higher and contiguous to mines, or any other deep ſubterraneous pits, for the reaſons already given; and on theſe principles, and by theſe means, it may be accompliſhed with little difficulty or expence.

The water found in the bottom of the pit or mine, muſt be got rid of in a different manner, as the ground may perhaps nowhere decline lower than the mouth of the pit. For it is only on the ſuppoſition of the different ſtrata and ſand-bed, *DIPPING* with the natural inclination of the ſurface, that the above method of proceeding is practicable, or on the ſuppoſition of their lying nearly horizontal; but, ſhould they lie in a reverſe direction, there is little poſſibility of accompliſhing the object, unleſs their termination can be hit on, ſomewhere on the oppoſite ſide of the hill, which, by aſcertaining the preciſe inclination of the metals, and by exact levelling, may very nearly be found out. In moſt caſes, however, the upper ſtrata above coal are found lying pretty regular.

But, as a deſcription alone, without an explanatory ſketch, cannot ſo clearly convey an idea of the nature of it, Fig. 1. of the annexed Plan, No. 10. will help to elucidate theſe remarks.

The foregoing obſervations ſo far explain how the water may

PLAN *representing the* DRAINAGE *of* MINES &c.

N.o 10.th

(SECTION Fig.1st)

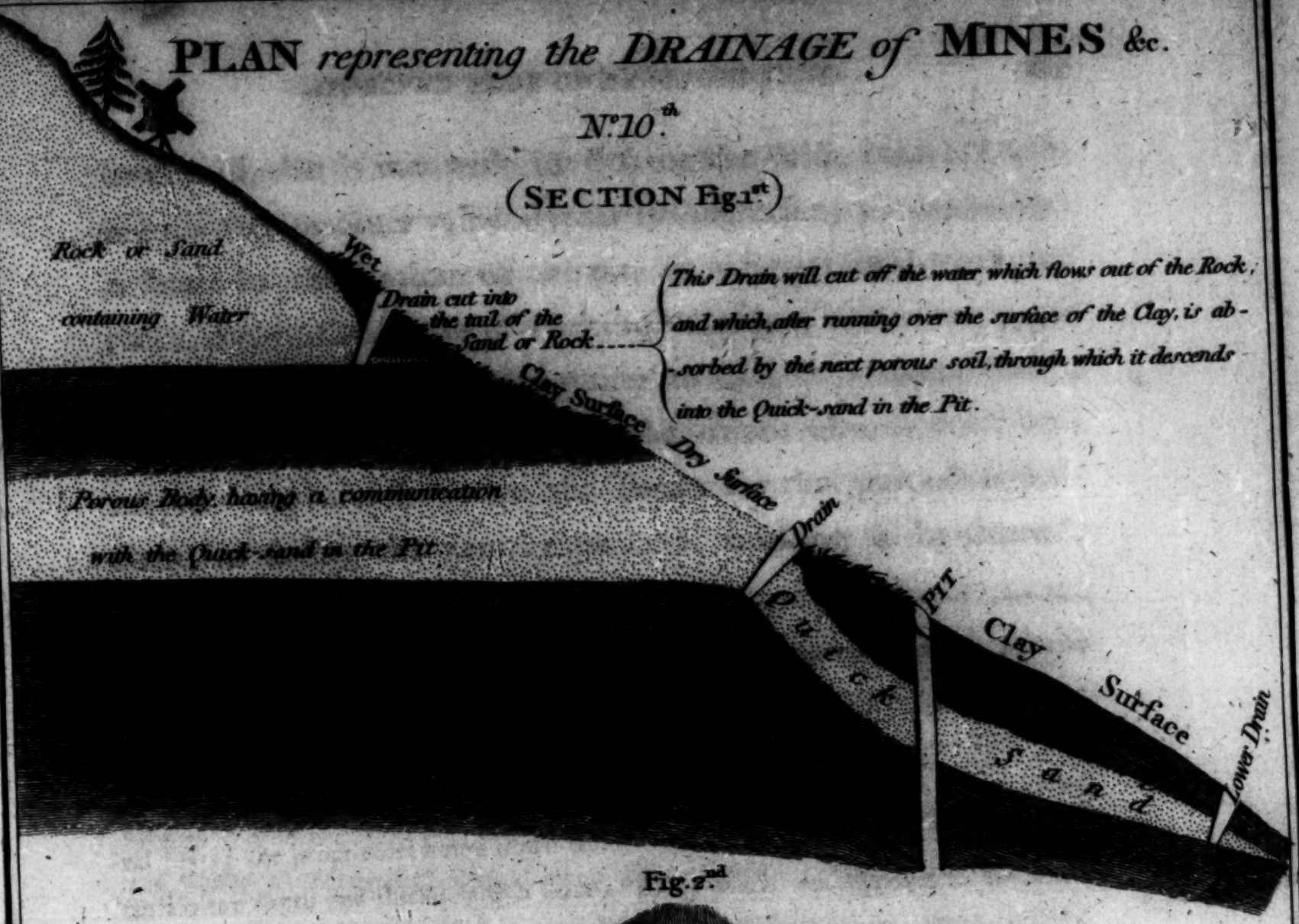
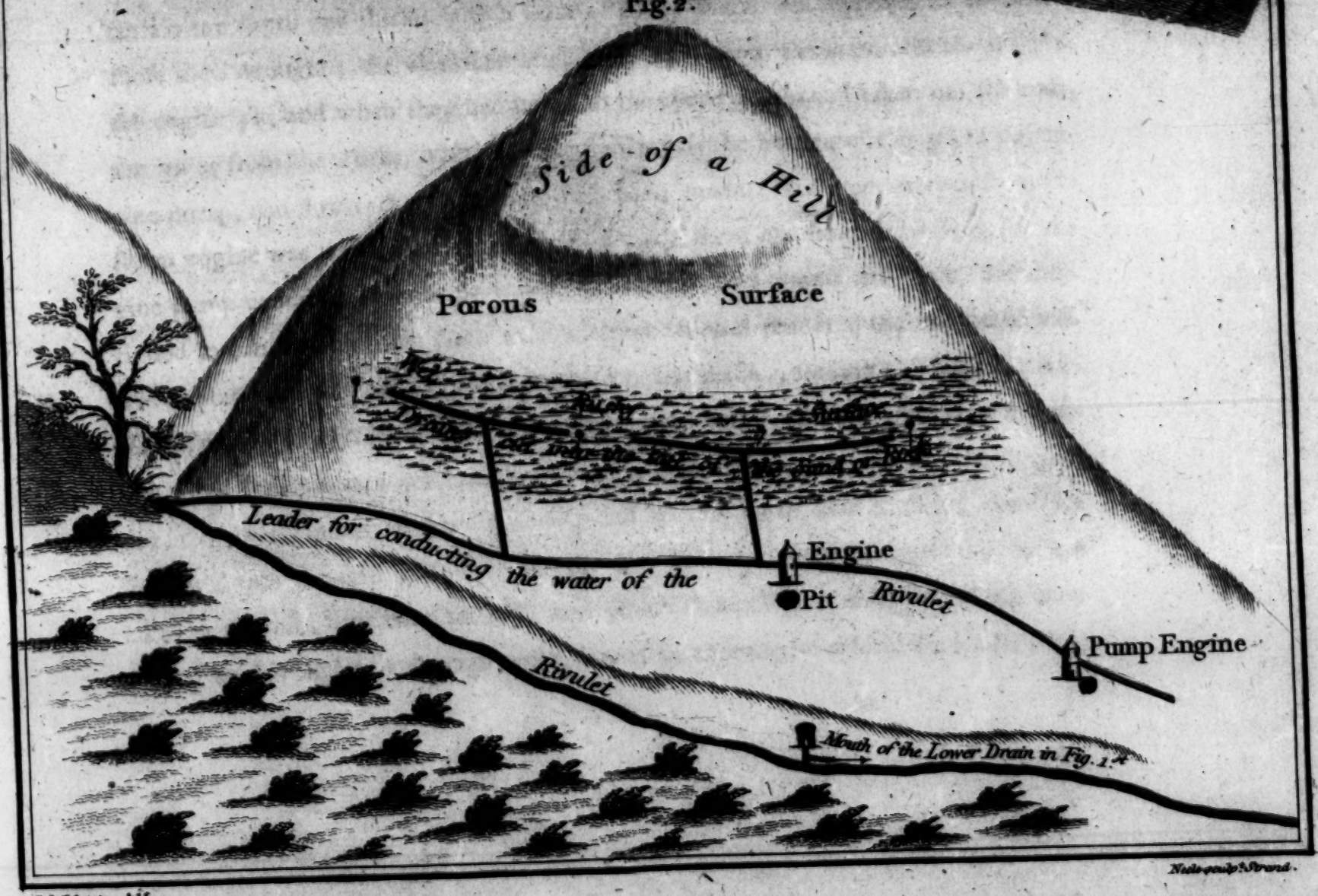


Fig.2nd



Nutt sculp.t Strand.

Jn.o Johnston del.t

be cut off, that is met with in ſinking the ſhaft, before reaching the coal or other mineral that is ſought for; the water that is found in the bottom of the pit, or what proceeds from the rocks, &c. in the courſe of working the mine, is commonly got rid of by means of an engine pump, to aſſiſt in working which, the water obtained by means of the drains already deſcribed, may be very uſeful, where the ſtream for that purpoſe is deficient, in ſaving the great expence of working it by ſteam *.

* THAT letting down the water by boring into an inferior open ſtratum, even in the bottom of the pit, may not only be practicable in ſome caſes, but of very great advantage, the following obſervations will ſhow: "The water was raiſed by a ſteam engine about ſixty yards, from a colliery in Yorkſhire, which had been wrought ſeveral years; the proprietors bored down to the depth of about ten yards farther, to aſcertain the depth and thickneſs of a ſeam of coals, which was ſuppoſed to lie below thoſe then wrought; the workmen employed bored from the bottom of the pit next the engine pit, and when they had bored to the above depth, and taken out the rods, the water from the works, which uſually ran acroſs the bottom of this pit to the engine pump, run down the hole they had then made. As ſoon afterwards as the ſteam engine was ſet to work at the ſtated period (about one hour in twelve), the engine pump contained little or no water; it had eſcaped through this hole, and continued to run through the ſame ever afterwards, and rendered the engine uſeleſs. This inſtance of water at ſo great a depth from the ſurface, finding a paſſage at a further depth of ten yards, or leſs, and immediately below, is very ſingular and ſtriking. The ſituation was much higher than the next adjoining valleys and the level of the ſea. Experiments of this ſort ſeldom fall to the lot of man to make, therefore ſuch inſtances are rare and uncommon. But in large tracts of level land, where lakes or moraſſes have been formed, and which cannot be drained by cutting open drains, or driving levels through rocks, but at an expence for which the lands, when

But, without the help of a natural ſtream, which may be converted to the above purpoſe, it is ſeldom poſſible to find, by means of drains or otherwiſe, a quantity of water ſufficient to drive ſuch weighty machinery, in a ſituation high enough to have the neceſſary command of it. It may, however, in many caſes, be a valuable acquiſition. See Plan 10. Fig. 2.

In ſituations where a proper command of water can be obtained, and where the entrance to the mine is likewiſe adapted for the purpoſe, the uſe to which it may be converted is ſtill more advantageous, by driving machinery to bring out the minerals, and alſo for working an engine pump, for clearing the mine of ſubterraneous water, flowing from the cavities of the rocks that are met with in working. His Grace the Duke of Buccleuch's coal works, near Langholm in Dumfries-ſhire, are a ſtriking example of this, and of the ſuperior powers of water and machinery when properly combined, where a command of the former can be obtained, and when the latter is conſtructed on proper principles, and conducted with that care and ingenuity which are neceſſary in ſuch undertakings.

It frequently occurs, in working quarries of lime or free-

---

drained, would never compenſate, the above inſtances warrant experiments being tried with bore-rods, which, if not ſucceſsful, may be tried at little expence." *Agricultural Report of Hertfordſhire*, page 67.

ſtone, that, at a certain depth, part of the rock containing water is hit on, whereby the quarry is ſoon ſo filled with water, as to put a ſtop to working it deeper, where the beſt of the ſtone lies. The common remedy in ſuch caſes is, either to erect a wind mill pump to draw out part of the water, (for the whole cannot be taken away by this means), or to open a new quarry adjoining to the laſt, which at the ſame depth meets with the like obſtruction, or to bring up a very deep and often expenſive cut, under the level of the water, from the neareſt declivity.

By the following method, however, all quarries of limeſtone, freeſtone, marl, &c. liable to ſuch an obſtruction, may be completely cleared of water at little expence; and the drain, at the ſame time, will ſerve a double purpoſe, by drying the wet ground, which, in conſequence of the ſpring contained in the rock, is found adjoining to it.

Immediately under the rock, commonly lies a bed of ſtrong retentive clay that upholds all the water received by and retained in that rock, and which being alſo bound round on each ſide by a covering of clay or other ſtiff ſoil, cannot diſcharge itſelf, and therefore ſtands always ſo full in the rock, as to prevent taking out the ſtone to the bottom.

In the firſt place, endeavour to find to what ſide the rock

DIPS or inclines, which may eaſily be found by the appearance of the ſurface in examining the adjacent ground, and by the aſſiſtance of a ſpirit-level. After diſcovering this, cut a drain through the clay covering to the rock, by which the water will be drawn off, that for want of a proper outlet, formerly ſtood pent up in the cavities of the ſtone. See Plan, No. 11. Fig. 1. and 2.

SOMETIMES the evil may be remedied in a different manner.

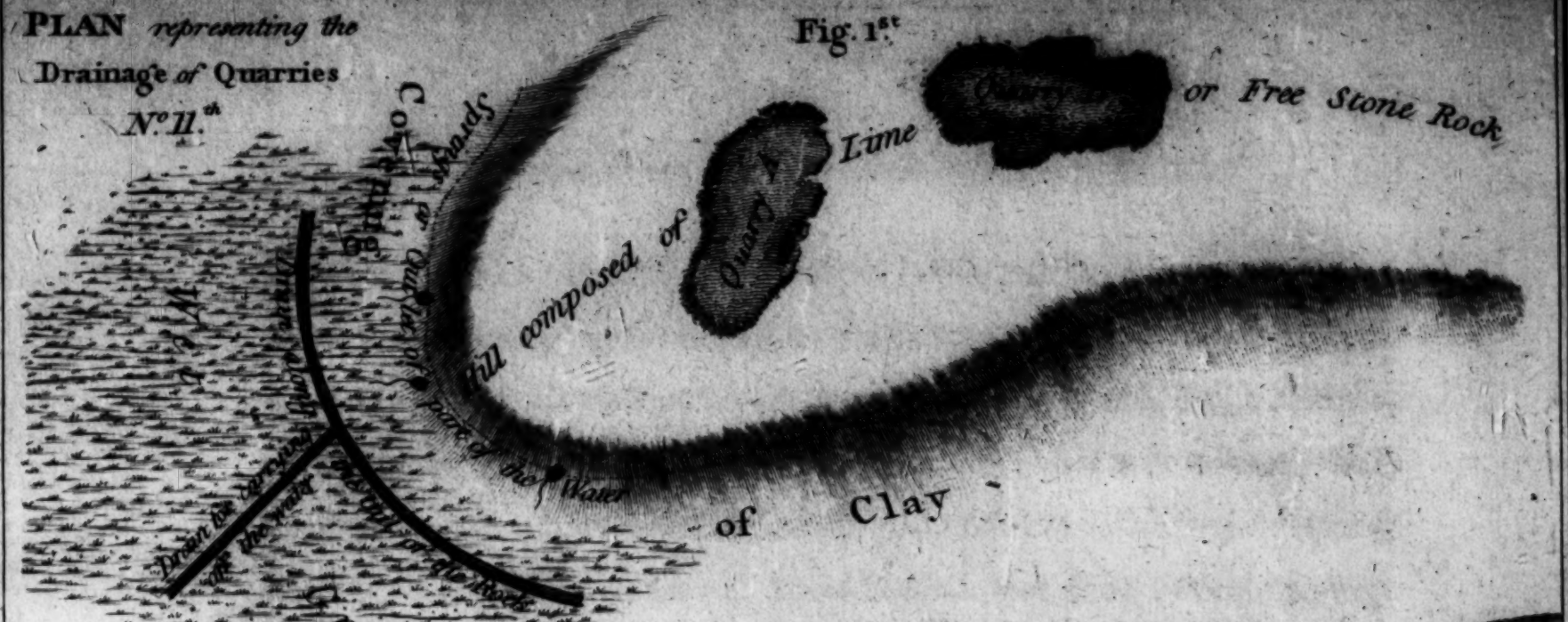
IT often happens, that a bed of the ſame ſtone, of a cloſe compact nature, is found lying under one of a more open kind with pores and fiſſures in it admiſſible of water, which ſo keeps up the water in the upper bed, that none of it can paſs through to an inferior open ſtratum; and on ſinking through this ſtone, another bed is found of ſo open and porous a nature, as to admit the reception of any water from above that may come into contact with it.

SOMETIMES a bed of gravel or ſand is found under the cloſe ſtone, which being ſtill more capable of abſorbing any water let down to it, is better calculated for the purpoſe of clearing the upper bed of ſtone from water, than a ſtratum of open ſtone itſelf.

G.R III
BRITISH MUSEUM

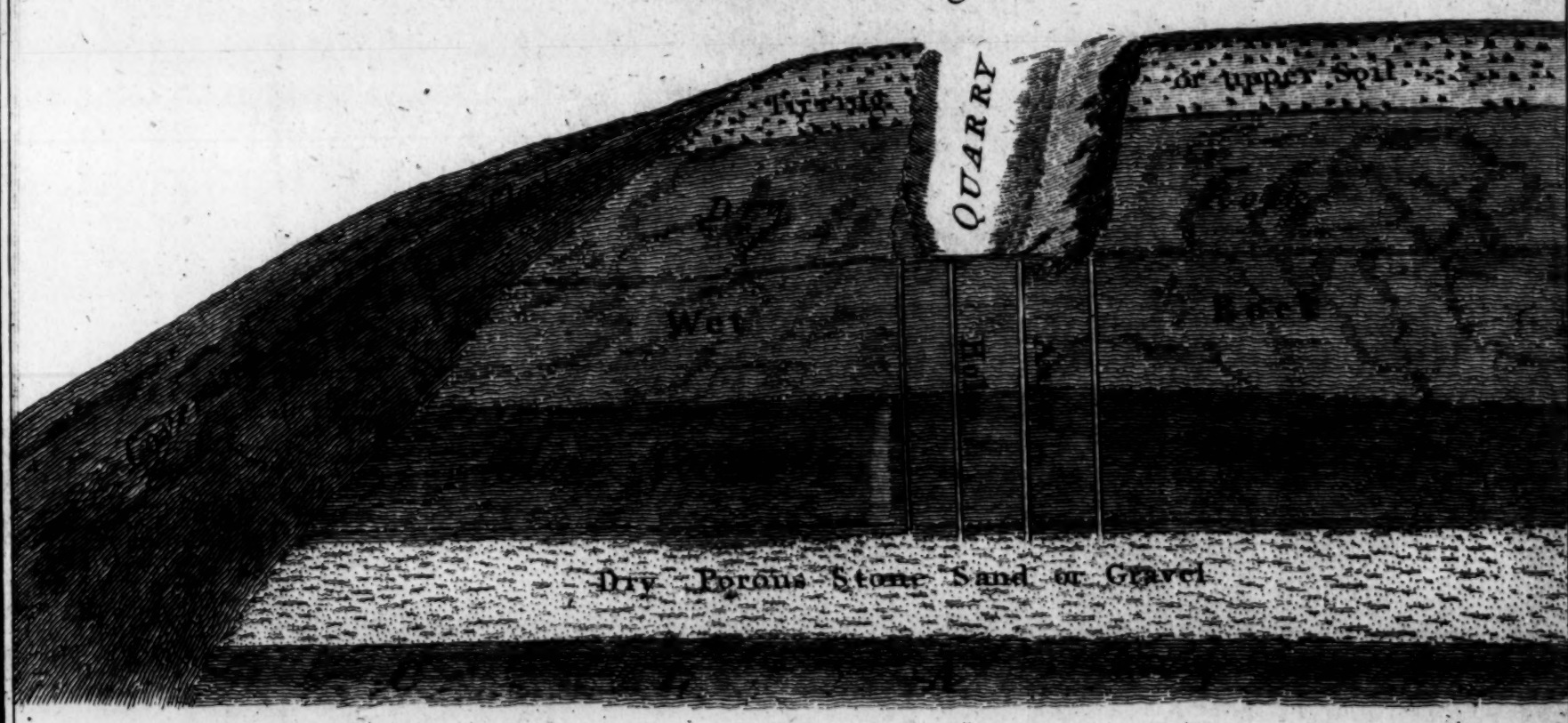
PLAN *representing the*
Drainage *of* **Quarries**
N.o II.th

Fig. 1.st



SECTION Fig. 2.nd

SECTION Fig. 3rd



Perhaps under this Clay Bed, there may be another dry porous Stratum into which the water may be let down, and reduced to a still lower level; and this may be ascertained by boreing an Auger Hole thro' the Clay.

J.n Johnston del.t *Neele sculp.t Strand.*

When this is discovered to be the case, and the water KEPT UP by the second bed of stone so as to be prejudicial to the working of the upper bed, and which will be equally so in working the second; the work may be greatly relieved by boring through the close bed of stone, and letting down the water into the more porous one below, or into a stratum of dry sand or gravel, if there be such under it. In place of boring, sinking small pits through the close stone is a more effectual method of letting down the water, but a more difficult one to execute.

At Ormskirk in Lancashire, stone quarries are cleared of water, exactly in the manner above described, which Fig. 3. in the annexed Plan will better explain *.

* To show the success of this practice, Mr Eccleston of Scarrisbrick, a very ingenious member of the Board, and proprietor in the neighbourhood of Ormskirk, communicated the following information:—"In stone quarries, wells (pits) occasionally are sunken to the open bed, which have proved serviceable. The above was practised in a stone delf near Ormskirk with success. But in order to lay the delf more effectually dry to a greater depth, Mr. Elkington having viewed the country, marked where he thought the rock terminated or tailed out, and at the lowest level set out a drain to be cut up to the rock, part of which work is executed, and a very considerable spring comes from it: but, on account of the great depth (sixteen feet), it will not be finished before he has seen the work again. The drain he has laid out is about ten feet lower than the bottom of the stone quarry, and when completed, will lay that head of stone dry lower than the present floor. All rocks mostly where they terminate, are succeeded by broken loose stones of the same nature as the

THE ſituation of marl pits is commonly ſuch, that it requires a very expenſive cut through ſome part of the ſurrounding bank, to carry off the water that prevents taking out the marl. This might often be accompliſhed in a much leſs expenſive manner, by ſinking a pit through the retaining ſtratum under the marl bed, into ſome abſorbent ſtratum below, that would receive the water let down into it by the pit. If the ground where the marl lies is of conſiderable extent, ſeveral pits will be neceſſary to carry off the water. If they require to be ſo deep as to be in danger of falling in, they ſhould be built round the ſides, or filled up to near the top with looſe ſtones through which the water can ſubſide. Any croſs drains or cuts neceſſary for collecting the water, muſt be conducted into the pits. In many caſes the water may be got rid of in a ſtill eaſier manner, provided the ſituation of the ground is anſwerable. If the ſurrounding bank declines on the oppoſite ſide *LOWER THAN THE WATER*, by cutting a drain into it, and boring with a *HORIZONTAL AUGER*, in to the *TAIL* of the ſtratum containing the water, it will be drawn off and reduced to a level lower than

---

rock, and they are frequently (not to ſay always) ſucceeded by ſand, which, when a thick bed, and of a running nature (quickſands), often cauſe great expence to cut through to the tail end of any rock." See Plan 11. Fig. 2.

IN ſuch caſes as this, where there is danger of meeting a quickſand, boring or ſinking pits through the bed of cloſe ſtone, is the moſt adviſable and leaſt expenſive method.

that of the bed of marl. As this water is often ſupplied by a ſpring, riſing in ſome part of the higher ground and deſcending into the place where the marl lies, in ſuch caſe it will be neceſſary to cut off the ſource of this ſpring, and divert it into ſome other channel. By doing this, the quantity of water below will be leſſened, and more eaſily carried off by means of the pits or drain.

that of the bed of marl. As this water is often supplied by a spring, rising in some part of the higher ground and descending into the bore, where the marl lies, in such case it will be necessary to cut off the source of this spring, and divert it into some other channel. By doing this the quantity of water descending to the level will be lessened, and more easily carried off by means of the

CHAPTER IX.

Obſervations on the Uſe of the Spirit-Level, and Directions for Uſing it in marking out of Drains, &c.

AFTER the *MAIN SPRING*, or that from which the others derive their ſource, has been diſcovered, the aſcertaining a line on the ſame level, to one or both ſides of it, for the better and more ſure direction of the drain, being one of the firſt and moſt important parts of the operation, and the one on which Mr. Elkington's art in a great meaſure depends (for before him it is believed, that no man ever thought of aſcertaining, by means of levelling, the courſe of water in the bowels of the earth), a deſcription of it may prove uſeful to thoſe who have never been in the practice of uſing the ſpirit-level for that purpoſe.

BEING provided with a ſpirit-level (which it is neceſſary to have previouſly adjuſted), and a ſtaff about ten feet in length, with a moveable vane or ſight affixed to it, ſet up the inſtrument in a ſituation between the object from whence the level is to be taken, and that to which it is to be directed, provided the diſtance from the inſtrument to each of them is not too great,

The ſituation of it ſhould alſo be no higher than the length of the ſtaff will anſwer, and ſo as it may be ſeen from it both ways; then direct the man with the ſtaff to hold it at the *MAIN SPRING*, or place from whence you mean to carry the drain; and, after directing the teleſcope to the ſtaff, and adjuſting it to a level, make a ſign to him to move the ſight up or down, till it be exactly oppoſite the croſs hair in the teleſcope. This done, without ſhifting the inſtrument from its firſt poſition, and cautioning the man to fix the ſight to the ſtaff at the point directed, he may proceed forty or fifty yards farther; and after having again adjuſted the level, make a ſign to him to move to *HIGHER OR LOWER GROUND*, till the ſight on the ſtaff coincide exactly with the croſs hair in the teleſcope. He may then leave a peg at the place where he held the ſtaff, and proceed in like manner to other ſtations, till the whole line is finiſhed, leaving pegs or making pits at the places where the ſtaff was held.

If the length of the line to be levelled requires the inſtrument to be ſhifted from its firſt poſition, the level muſt again be taken from the laſt ſtation where the ſtaff was held, and the ſight on it fixed in the proper place, as before directed, proceeding in the ſame manner at every forty or fifty yards in length, till the whole is accompliſhed. After the line is thus levelled, and aſcertained by marks left at every ſtation where the ſtaff was fixed, it may again be examined, and other pegs put in between the firſt, the better to direct the workmen in cutting the drain,

giving the line ſuch turnings, and even ſmall deviations from the courſe of the level, as may ſhorten or ſtraighten it, and humour the ſituation of the ground.

For the ſake of accuracy, where the work requires it, eſpecially if the water is to be conveyed any conſiderable diſtance, or wanted to ſupply a houſe, or for the purpoſe of irrigation, the levels may be proved by reverſing the former line of direction. The ſpirit-level is alſo neceſſary for aſcertaining how much fall can be obtained from the drain to the neareſt outlet where the water can be diſcharged, the ſhorter that diſtance being the better, provided fall enough can be got.

It is often neceſſary to level a much longer diſtance than the length of the drain may require to be cut; but when the level of the whole line is known, and the nature of the ground carefully examined, ſhort drains can be cut on that line, with openings (places not dug out) between, which will anſwer the purpoſe equally as well as one the whole length; and the expence will be conſiderably leſs, provided the length of the conductors for the water from each, be leſs than that of the openings or places not cut: But if the whole line, with only one conductor, be ſhorter than theſe, it is better to have all the water diſcharged at one orifice. The level has frequently to be taken from a ſpring or well, at a conſiderable diſtance from the ground to be drained.

THE American level, as it is ſometimes called, being firſt communicated to the Preſident of the Board of Agriculture by Dr. Edwards of America, is ſo ſimple and uſeful an implement for aſcertaining the level of drains or water courſes, that I have thought proper to ſubjoin a deſcription of the method of uſing it, and have given a drawing of it in Plate 12. No. 5.

IT is formed of two pieces of thin wood of equal length, joined together at top, and connected below by a croſs bar. From the angle at top, a lead plummet is ſuſpended by a ſmall cord, which, when the inſtrument ſtands level on both legs, ſtrikes upon a mark in the centre of the connecting bar, as repreſented by Fig. 5. in the Plate. The manner of uſing it is ſimply thus: At the place from whence the level is to be taken, drive a wooden peg into the ground, cloſe in to the top, upon which one of the legs of the frame may reſt; then bringing round the other leg till it touch the ground, there drive in a ſecond peg, and the ſpace betwixt them will be level. In proceeding forward, reſt the leg of the frame upon the top of the ſecond peg, turning round the other leg as before; and where it touches the ground again drive in another peg, and ſo on along the whole line to be levelled. Thus, with very little trouble, and with as much accuracy as with the fineſt ſpirit-level, will the courſe of the drain be eaſily aſcertained. But, as it is neceſſary that the drain ſhould have as much declivity as to allow the water to run freely, it will be requiſite in taking the

level, to regulate the direction of the line accordingly. Half an inch fall in the length of the frame will be ſufficient. For this purpoſe it will be expedient to have, beſides a number of wooden pegs, one iron pin, with inches and halves marked regularly upon the ſides of it, from the top downwards. After having drove in the firſt wooden peg at the point from whence you mean to conduct the drain, and having reſted the one leg of the frame upon it, turn round the other till it be level with the firſt peg. There put in the iron pin, ſo that this leg of the frame may reſt on the top of it when level; then drive in a wooden peg ſo far, as that the top of it may be one half inch lower than that of the iron pin. Place the leg of the frame again upon this ſecond peg, turn it round to a level, putting in the iron pin till the top of it be equal with the foot of the frame; then drive in another wooden peg cloſe by the ſide of it, till the top of the wooden one be half an inch lower than that of the iron pin. Proceed in this manner ſo far as you mean to carry the drain, which will have the ſame degree of declivity all the way along. A line thus ſet off is marked from A to D in the Plate. When made on a ſmaller ſcale, it is uſeful in aſcertaining the proper deſcent along the bottom of the drain, while the workmen are laying it; but when made for this purpoſe, the croſs bar muſt be fixed to the bottom of the legs, as marked with dotted lines in the Plate.

level, to regulate the direction of the line accordingly. Hold an inch tape in the length of the frame will be sufficient. For this purpose it will be expedient to have, perhaps a number of wooden pegs, one inch big, with inclined planes, marked respectively upon the sides of it, from the top downwards. After having driven in the first wooden peg at the point from whence the distance is to be measured, and which will prove the same throughout the whole, and having refixed the one leg of the tape line at the top of it, as near the head inch wooden peg to that, as right the top of it will be one half inch lower than that of the inch big. Place the leg of the frame against upon this second peg, and it must to a level, pointing in the inch big till the top of it be equal with the foot of the upper part of the frame; then drive in another wooden peg close by the side of the inch big till the top of it be half an inch lower than the top of the wooden one be level with the foot of the upper part of the frame. Proceed in this manner to the as you see in the figure. Which will prove the same degree of declivity all the way along. A line these feet or ft is marked from A to D in the Plate. When made on a finished scale, it is ascertaining the proper declent along the portion of the



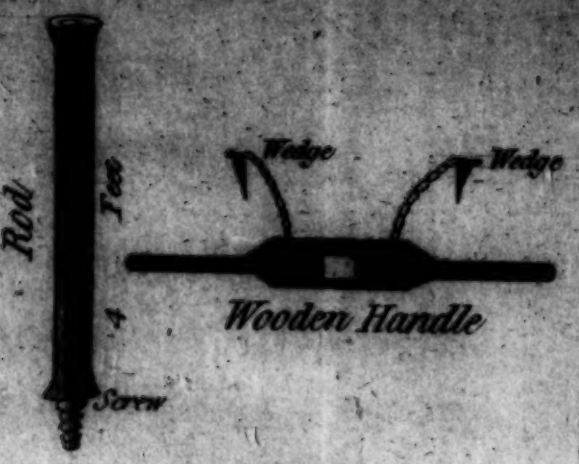
PLAN N°. 12





Bottom Shovel with edges turned up



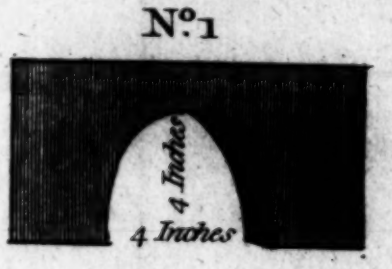








N°. 1

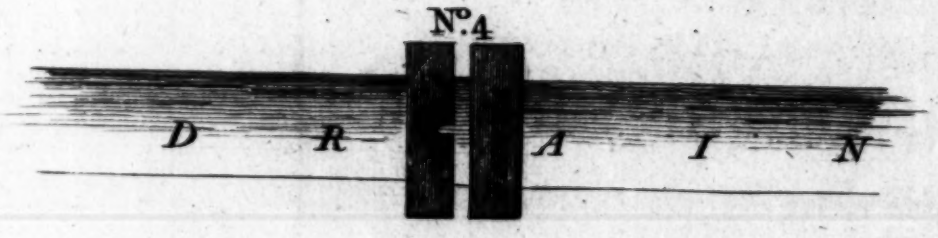


N°. 2

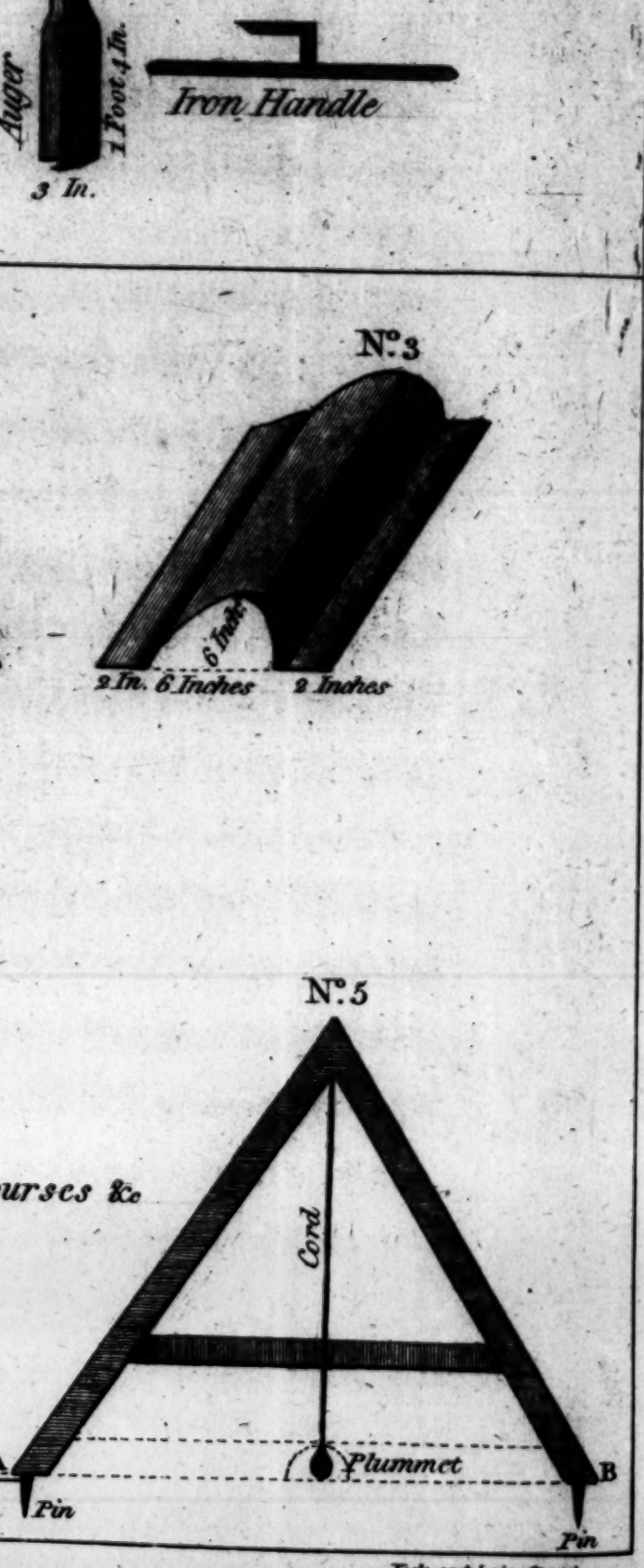


N°. 3

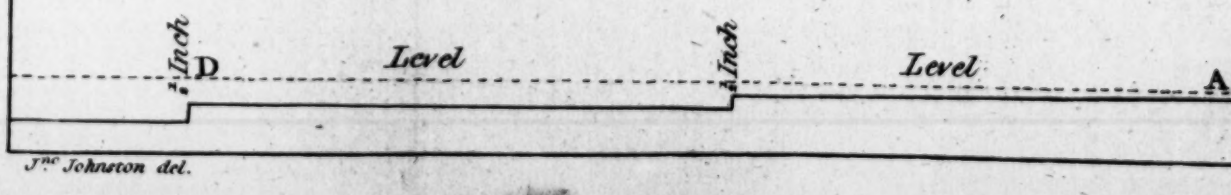
N°. 4



N°. 5



Instrument for Levelling Drains & Water Courses &c



Jnº. Johnston del.

Neele sculp.t 352 Strand.

CHAPTER XI

Description of the Auger, and Manner of Using it, &c.

THE borer uſed in draining is nearly ſimilar to that made uſe of in ſearching for coal or other ſubterraneous minerals. The auger, ſhell, or wimble, as it is variouſly called, for excavating the earth or ſtrata through which it paſſes, is from two and a half to three and a half inches in diameter; the hollow part of it one foot four inches in length, and conſtructed nearly in the ſhape of the wimble uſed by carpenters; only, the ſides of the ſhell come cloſer to one another. The rods are made in ſeparate pieces, of four feet long each, that ſcrew into one another to any aſſignable length, one after another, as the depth of the hole requires. The ſize above the auger is about an inch ſquare, unleſs at the joints, where, for the ſake of ſtrength, they are a quarter of an inch more. There is alſo a chiſel and punch for ſcrewing on, in going through hard gravel or other metallic ſubſtances, to accelerate the paſſage of the auger, which could not otherwiſe perforate ſuch hard bodies. The punch is often uſed when the auger is not applied, to prick or open the ſand or gravel, and give a more eaſy iſſue to the water. The chiſel is an

inch and half or two inches broad at the point, and made very ſharp, for cutting ſtone, and the punch an inch ſquare like the other part of the rods, with the point ſharpened alſo. There is a ſhifting handle of wood, that is faſtened with two iron wedges affixed to it, for the purpoſe of turning round the rods in boring, and alſo two iron keys for ſcrewing and unſcrewing the rods, and for aſſiſting the handle when the ſoil is very ſtiff, and more than two men required to turn it.

To judge when to make uſe of the borer is a difficult part of the buſineſs. Some who have not ſeen it made uſe of in draining, have been led into a miſtaken notion, both as to the manner of uſing it, and purpoſe for which it is applied. They think, that if by boring indiſcriminately through the ground to be drained, water is found near enough the ſurface to be reached by the depth of the drain, the proper direction for it is along theſe holes where water has been found; and thus make it the firſt implement that is uſed. The contrary is the caſe, and the auger is never uſed till after the drain is cut; and then, for the purpoſe of perforating any retentive or impervious ſtratum, lying between the bottom of the drain and the reſervoir or ſtrata containing the ſpring, Thus does it greatly leſſen the trouble and expence that would otherwiſe be requiſite in cutting the trench to that depth, to which, in many inſtances, the level of the outlet will not admit. The manner of uſing it is ſimply thus: In working it, two, or rather three men are neceſſary.

Two ſtand above on each ſide of the drain, who turn it round by means of the wooden handle; and when the auger is full, they draw it out, and the man in the bottom of the trench clears out the earth, aſſiſts in pulling it out, and directing it into the hole, and who can alſo aſſiſt in turning with the iron handle or key, when the depth and length of rods require additional force to perform the operation. The workmen ſhould be cautious, in boring, not to go deeper at a time, without drawing, than the exact length of the ſhell, otherwiſe the earth, clay or ſand, through which it is boring, after the ſhell is full, makes it very difficult to pull out. For this purpoſe, the exact length of the ſhell ſhould be regularly marked on the rods, from the bottom upward. Two flat boards, with a hole cut into the ſide of one of them, and laid alongſide of one another over the drain, in time of boring, are very uſeful for directing the rods in going down perpendicularly, for keeping them ſteady in boring, and for the men ſtanding on when performing the operation, (No. 4. in Plate 12.) The other implements uſed in cutting the drain, are, beſides the common ſpade and ſhovel, thoſe repreſented in the Plate. The hollow ſpade, made of oak timber, and ſcooped out in the middle, is uſed in ſoft peat ſoils, being light and eaſy to work with, and the edges preventing the earth from falling off, when throwing it out of the trench. They are made of iron in the ſame ſhape alſo, for throwing out clay or tough ſoil. The crooked handled ſpade or ſhovel, having the edges turned up, is well adapted for

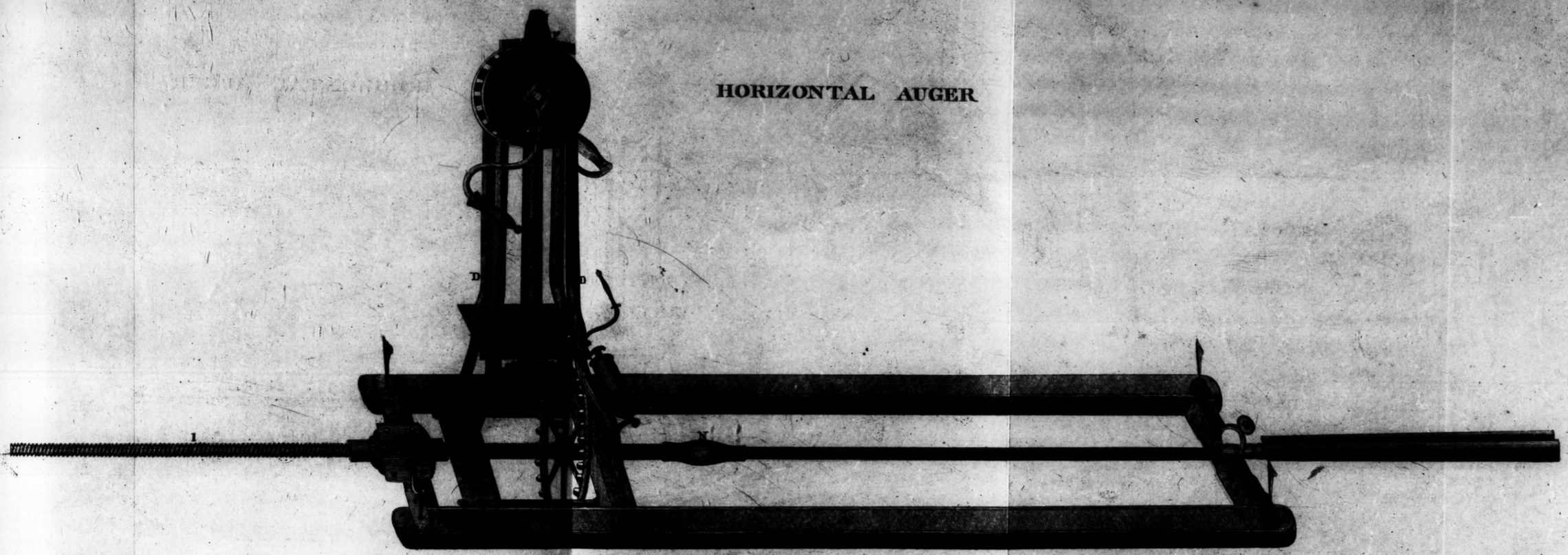
ſmoothing the bottom of the drain before laying the ſough, and with which the workmen have leſs occaſion to ſtoop. As the common opening of the ſough is ſix inches ſquare, a piece of wood of that ſize, and one yard in length, is very uſeful for laying in the bottom of the drain, and building the ſtones on each ſide of it, and which can be ſhifted forward as the workman proceeds in forming the ſough.

Of the Horizontal Auger.

THIS inſtrument was lately invented by Heafield of Hather in Leiceſterſhire, and is not yet come into general uſe. The advantages of it are in many caſes conſiderable, by leſſening the expence of otherwiſe cutting, and performing the work in a much ſhorter time. Where a dram or water courſe has to paſs under a bank, road, hedge, wall, rivulet of water, or for drying marl pits, &c., it may be uſed to advantage in excavating a ſufficient paſſage for the water, without opening a trench. In laying leaden pipes for the conveyance of water, it is alſo uſeful, in making a hole in which the pipe may be laid, without opening a cut on purpoſe.

FOR tapping ſprings, or finding water at the bottom of a hill, either for the ſupply of a houſe, or for draining the ground, it may be uſed with ſucceſs, as the water of the ſpring, when hit on, will flow more eaſily, and in greater abundance, through a horizontal or level, than through a perpendicular outlet.

HORIZONTAL AUGER



EXPLANATION

AA *Frame groved within 8 Feet 10 Inches.*

BB *Ends of the Frame 2 F. 10 Inches through which the Screw and Auger passes.*

CC *Bottom of the Carriage to which the Uprights are fixed.*

DDDD *Upright Standards 4 F. high.*

E *Spindle 2 Feet 10 Inches long.*

F *Upper Cog with ten teeth.*

G *Lower Cog with 24 teeth.*

H *Main Wheel with 32 Dº*

I *Screw 6 Feet 3 Inches.*

K *Auger 6 Feet long and 3¼ Inches diameter.*

L *Winch & Roller for reversing the Rods.*

M *Two contright or side wheels with 24 cogs each, upon which the two handles are fixed.*

N *Joint for lengthning the Rods.*

THE manner of uſing it is thus: Suppoſe a lake or pond of water, ſurrounded with high banks, to be emptied, if the ground declines lower on the oppoſite ſide, find the level of the bottom of the water, and trace that level to the face of the bank where the perforation is to be made. There ſmooth the ſurface of the ground ſo as to place the frame nearly level, with the auger pointing a little upwards. It requires two men to turn the handles at top, in order to work it, which may be better underſtood by examining the Plate. When the auger or ſhell is full, the rods are drawn back by reverſing the lower handle, and rods added at the joint when the diſtance requires. In boring through a bank of the hardeſt clay, two men will work through from thirty to forty feet in a day, provided there is no interruption from hard ſtones, which will require a chiſel to be fixed on in place of the ſhell, and longer time to work through. If the length to be bored through is conſiderable, or longer than the whole length of the rods, a pit muſt be ſunk upon the line, down to the hole, for placing the frame when removed, and the operation carried on as before.

CHAPTER XI.

Extracts from ſome of the Agricultural Reports of thoſe Counties in England where Mr. Elkington has executed the moſt remarkable Drainages, tending to authenticate the Advantages derived from his Practice.

I SHALL begin with Warwickſhire, being Mr. Elkington's native county, and the one in which he firſt made the diſcovery.

COUNTY of WARWICK, by John Wedge.

"DRAINING is, without doubt, the firſt ſtep towards the improvement of all wet land; it has been practiſed with much ſucceſs in this county for ſeveral years, but more particularly ſo ſince Mr. Elkington, a farmer in this diſtrict, introduced a method of draining boggy lands, by making deep drains, and boring at the bottom or ſides of them through the different under ſtrata, ſo as to tap the ſprings, and thereby, in many inſtances, cure large tracts of land with very few drains. The novelty of this practice here, and Mr. Elkington's myſterious manner, in declaring he knew where, and in what direction the different

ſtrata of the earth divided, and at what particular point an auger hole might be bored, to lay dry this or that particular ſpring or well, were matters which attracted much notice, and occaſioned great ſurpriſe; and it is but juſtice to Mr. Elkington to ſay, that in one claſs of bogs, &c. which abound as much as (perhaps more than) any other, he has not only had the honour of introducing the auger in this county, but the merit of laying effectually dry many large tracts of land."

County of Leicester, by John Monk.

"The moſt capital improvements have been made under the direction of a Mr. Elkington, who is ſuppoſed to be the firſt in that line in the world. After forming the drain, by beginning at the fall and working upwards, he makes uſe of a borer to find the ſpring, with which he generally ſucceeds, which has a wonderful effect in draining the land. It is ſaid that he has a very quick and certain method of finding where the ſprings lie, peculiar to himſelf. By the uſe of the borer, Mr. Aſtley * had a piece of land drained without going into it, by the following circumſtance: Mr. Elkington was employed in draining a piece of land belonging to Mr. Richard Aſtley, which was ſeparated from his brother's by a ſmall river or deep rivulet.

---

* Of Odſtone Hall.

Mr. E. finding the ſpring at about ſixteen feet from the ſurface (under the bed of the river), completely drained both pieces. I was informed, that ſome time ſince, Mr. Elkington was engaged in draining a piece of land near Lutterworth; and ſoon after he had found (ſome call it tapping) the ſpring, the inhabitants, to their very great ſurpriſe, found their wells all dry. After inveſtigating the cauſe, it was found that Mr. E. had been the means of it, by cutting off the ſpring which ſupplied the town with water.

"I MENTION the above two inſtances merely to ſhow what a wonderful effect the borer has, and what a very capital inſtrument it is for draining," &c.

"I DO not mean to ſay that Mr. E. is the only perſon that makes uſe of the borer; for there is ſuch a very great ſpirit for this kind of improvement, that there are very few of the beſt farmers without this inſtrument. Mr. Elkington has ſo much buſineſs, that it is with great difficulty he is to be had when wanted."

COUNTY of DERBY, by Thomas Brown.

"BUT every other method ſeems to bend to that practiſed by Mr. Elkington, whoſe practice is becoming every day more extenſive, and ſeems to me the moſt effectual of all others for carrying off ſubterraneous waters. He lays a

ſtone drain from three to ſix feet below the ſurface, in ſuch a direction as to cut the ſource of the ſpring, and with ſuch a declivity as to ſcour itſelf. Wherever he finds the ſource of the ſpring below the level of his drain, he bores, and with ſuch judgment, that, to a ſtranger, his auger ſeems poſſeſſed of the virtue of that rod with which Moſes ſtruck the rock; for the water immediately guſhes out, and perhaps lays land that before was too wet to carry a ſheep, ſufficiently dry to carry the heavieſt ox. This method certainly is effectual againſt ſprings."

County of Suffolk, by Arthur Young, Eſq. Secretary to the Board of Agriculture, &c. &c.

"It will not be improper to hint, that there are two errors very common in the performance of this improvement. The firſt is, making the drains in, or nearly in, the direction of the declivity; whereas they ought always to be made obliquely acroſs it: The other is, that of marking out and making numerous drains acroſs the ſides of ſpringy hills, which might, in many caſes, be drained completely with a ſingle drain, judiciouſly diſpoſed, according to thoſe obvious principles upon which the celebrated drainer, Mr. Elkington of Warwickſhire, proceeds. No improvement can have greater or more immediate effects than this of draining; none that pays the farmer with more certainty."

COUNTY of STAFFORD by William Pitt.

" ATTEMPTS have been made to tap ſprings, by boring into them, by Mr. Elkington *AND OTHERS*, and ſometimes with ſucceſs."———

MR. PITT, in ſpeaking of the improvements in Fiſherwick Park, ſays,

" HERE the genius of a Brown, aided and ſeconded by the munificence of the noble owner *, have conſpired to render a dreary moraſs one of the moſt delightful ſpots in nature, and have in a great meaſure ſucceeded: which ſucceſs is ſtill further heightening by the improvements of Mr. Elkington, in the interception of ſprings, and the diſcharging of ſtagnant water."

COUNTY of WORCESTER, by W. J. Pomeroy.

" IN ſpeaking of under drains, it may be thought right to mention, that various experiments have been made at Ewell-Grange, the ſeat of the Earl of Plymouth, and in that neighbourhood; but that by boring after Mr. Elkington's method,

* Marquis of Donegall.

deſerves to be moſt particularly noticed, which, indeed, in ſuch ſituations, (viz. low, fenny, or boggy lands), ſeems to ſuperſede the uſe of every other."

Extracts from the Annals of Agriculture, by A. Young, Eſq. &c. &c. Vol. XVI. Anno 1791.

" Aug. 5.—RODE to examine ſome works carrying on under the direction of Mr. Elkington, a ſingularly able drainer, whom I ſhall have more occaſions than one to mention."——

" The chief object of our ride was to view Mr. Elkington's works, who, we were informed, was engaged by ſome of the owners of theſe mills *, to bring them more water, by draining ſome boggy ſpots, from which the ſprings ariſe. We viewed his trenches for this purpoſe: it ſeems that this moſt ingenious operator had contracted with the millers, to be paid only in proportion to the additional quantity of water he procured for them. As we viewed his drains, and the general declivities of the waſtes around, a queſtion aroſe amongſt us upon the poſſibility of procuring more water by any drains, or cuts, or boring, than flows already in a more diffuſive manner through bogs;——*EXCEPT* by bringing water to take a direction on one

* Near Sutton Collfield in Staffordſhire.

ſide of a hill, which in its natural courſe flows out on another ſide."——————" But Mr. Elkington's practice is remarkable in one circumſtance, *AND DIFFERS FROM ANY DRAINER I HAVE YET KNOWN.* From diſtance to diſtance at the bottom of his ſurfs *, which are of various depths, from three and four to ſix and ſeven feet, he bores with a common iron boring rod, five or ten lower, and in doing this often finds the water riſe quickly in the hole. By this operation, it ſhould ſeem, that he has Mr. Bakewell's idea in contemplation †; and it is to be noted, that by this practice, he in many caſes, by a ſingle drain, lays lands dry that were not at all in the contemplation of the perſon who employs him, even to a conſiderable diſtance. Suppoſing ſprings to lie in ſtrata, nearly on a level, and to communicate from ſide to ſide of the largeſt hills, in ſuch caſe it does not ſeem at all improbable, but that, by draining and boring deeply on one ſide, you may procure more water than came before, by diverting it from the uſual courſe; ſo that, by carrying on works of this ſort on one ſide of a mountain, the other ſide at ſome miles diſtance may be drained. Thus the millers on one ſide of a hill may pay Mr. Elkington for bringing water to their dams, and the millers on the other ſide of the hill proſecute him for depriving them of theirs; which, it muſt be confeſſed, would be a laugh-

* Or *SOUGH*, the conduit, or bottom part of the drain, formed with brick or ſtones.

† See Annals of Agriculture, Vol. XVI.

able litigation."——"Such works, however their operation, cauſes and conſequences, have infinite merit, and do great credit to the talent of this very ingenious and uſeful man, who will have the merit, wherever he goes, of ſetting men to think."——

"THE 6.—To Aſhby de la Zouch; called in our way on Mr. Marſhall, to view a bog of ſeveral acres, drained by Mr. Elkington, which he effected with his uſual ſucceſs.

THIS bog was occaſioned, as they commonly, or rather always are, by ſprings, which he pierced into by means of a deep drain, boring at the bottom of it, as above deſcribed; the ſurf in this dry ſeaſon runs no inconſiderable ſtream. The whole is now under oats, a very fine crop, on land, which before was of no value whatever."——

"Mr. Elkington has been employed by Mr. Knowles* to drain the ſlope of a hill poiſoned with ſprings; in every inſtance of his draining, I hear ſome new circumſtance, to prove the ſagacity and ingenuity of this ſkilful operator, who may be termed an engineer of a new order. The crown of the hill above Mr. Knowles's wet fields is all dry, ſound, gravelly land,

* Of Nelſon in Lieceſterſhire. In a certificate ſent to the Board of Agriculture, Mr. Knowles ſays, that this land, by means of Mr. Elkington's drains, was rendered worth 30s. or 40s. an acre, which before was not worth half a crown.

in which no ſigns of ſprings, becauſe pervious to water in its level; but when theſe ſprings came to the fields in queſtion, which are clayey, they riſe to the ſurface proportionably to the quantity of clay which impedes their progreſs; in this caſe he found, by taking the levels, that ſprings on the other ſide of the hill in a clayey ſpot, at the diſtance of ſome hundred yards, were exactly on the ſame level as theſe paſſing under the gravel on the elevation, and thus breaking out where the paſſage was obſtructed, by variation of ſoil. And he pronounced, that when this is the caſe, one ſurf, ſkilfully marked, will drain a variety of different and even far diſtant fields; and he recommends, in ſuch caſes, to wait, after the firſt drain is made, to let its operation take place, for ſix months, or even a twelvemonth; in which time it will be found, how far the effect has taken place: if more are wanted, they can be made. When ſprings are brought in this manner from a diſtance, there is no doubt but he brings more water to a place than flowed in it before. The great ſkill is to know where to bore. The ſurf or French bricks which he uſes, are eight ſhillings a thouſand more than common ones."

In a treatiſe, lately publiſhed; "On the neceſſity and advantages of care and economy in collecting and preſerving different ſubſtances for manure," by Thomas B. Bayley, F. R. S. is the following obſervation:—

"IT may reaſonably be expected, that at no very diſtant period, the peat moſſes of Great Britain and Ireland will be drained, and brought to the higheſt ſtate of fertility. Their preſent ſuperabundant moiſture renders them not *MERELY* unproductive waſtes, but extremely injurious to the drier lands in their vicinity. The invention and energy of a Wakefield* and an Elkington, in reclaiming and improving moſſes, cannot fail to excite a general imitation of the very ſucceſsful proceſſes by which they have rendered theſe bogs productive of plenty; with the additional happy effects which thoſe improvements never fail to produce on the *CLIMATE*, *TEMPERATURE*, and *VEGETATION* of all the countries adjacent to them."

SUBJOINED is part of a letter, received from Charles Townley, Eſq. of Townley, in Lancaſhire, reſpecting Mr. Elkington's method of draining, and the improvement made on the ground, by means of his drains.——

——————————Reſpecting the mode of executing theſe drains, it differs from the common practice of making hollow drains, only by their being cut much deeper, and by boring with an auger either to increaſe the runs of water from

---

* Of Liverpool. Mr. Wakefield has lately made wonderful improvements upon the great Trafford Moſs near Mancheſter in Lancaſhire.

the ſprings when they are arrived at, or to give them vent when they lie too deep for the ſpade to reach them. Mr. Elkington's art, or knowledge of draining, lies, as you muſt know, in judging of the preciſe place where the pernicious ſprings can be caught; and in carrying them off in the cheapeſt and moſt advantageous manner. The mere plan of a drain can give little inſight into this kind of knowledge; I ſhould think, the beſt mode of conveying the ſyſtem, by plans, to the conceptions of others, would be, to compoſe ſections of the different circumſtances that moſt generally occur in the various ſtrata and runs of water, below the ſurface of the earth, and of the moſt proper ſituations of the drains that are to catch them. I will only repeat, that thoſe drained *BOGGY LANDS* that have had the proper manure laid upon them are not only made dry, but the herbage produced on them is become excellent, from having been, previous to the drainage, of very little value; and thoſe drained lands which have as yet received no manure, are rendered equally dry, and the coarſe and uſeleſs herbage, with which they were wholly covered, is viſibly giving way to better graſs. The proper manure will ſoon be laid on them, after which, I am perſuaded, the whole herbage will be excellent: The drains were only finiſhed laſt year.

Townley, 28th September 1796. (Signed) CHA^{s}. TOWNLEY.

Copy of a Letter and Certificate from Mr. John Maughan to Sir John Sinclair, Baronet.

Sir, *Hinckly, 25th October* 1796.

I am extremely ſorry at having taken ſo long a time in returning the certificate you wiſhed me to ſend, but I waited to ſee the effect of a drain I had ſet out for Mr. Jennings of Harlington, Bedfordſhire, a nephew of the late Mr. Whitebread's; or I ſhould have ſent it ſooner. The land I drained for him, had, about two years ago, been attempted to be drained in the common mode, and a conſiderable ſum of money had thereby been expended to no purpoſe, as the land, at the time I undertook to drain it, was as wet as ever. I have the ſatisfaction of ſaying it is now the drieſt land on the eſtate, and made ſo at an expence which does not exceed one twentieth part of what it had formerly coſt, by attempting the common mode of draining. I am, Sir, your obedient humble ſervant,

(Signed) JOHN MAUGHAN.

Copy of the Certificate.

I John Maughan of Luton in the county of Bedford, land-ſurveyor, late ſteward to Thomas Powys, Eſq. M. P. do hereby certify, that, in conſequence of a recommendation from the

Board of Agriculture, I waited on Mr. Elkington, who very readily communicated to me the principles of his art of draining land, which I have ſince practiſed myſelf with great ſucceſs, and to the ſatisfaction of thoſe who have employed me. And I hereby farther certify, that I have found Mr. Elkington's mode of draining of the greateſt public utility; that I have ſeen land of little or no value, when drained on Mr. Elkington's principles, made worth forty or fifty ſhillings per acre, and producing the richeſt crops both of corn and graſs:—In ſhort, that no mode of improving wet land equals it for public utility.—Witneſs my hand, this 25th day of October 1796.

BESIDES the above, many other communications and certificates, teſtifying the great advantages that have been derived from Mr. Elkington's practice, and what are likely to reſult from the knowledge of his ſyſtem being generally underſtood, might have been added; but as moſt of theſe have already been made public by the Board of Agriculture, in a former paper on that ſubject, what I have inſerted here may be ſufficient to convince the public of its utility.

APPENDIX,

CONTAINING

HINTS FOR THE IMPROVEMENT OF BOGS, &c. AFTER BEING DRAINED;

TOGETHER WITH

OBSERVATIONS ON HOLLOW AND SURFACE DRAINING IN GENERAL.

APPENDIX

APPENDIX.

Hints for the Improvement of Bogs, after being Drained.

THE next thing to be conſidered after a bog or piece of marſhy ground has been completely drained, is, the means moſt eaſily accompliſhed, and beſt adapted for its further improvement. If the bog is overrun with ruſhes, and other coarſe aquatics, nothing will tend ſooner to the firſt part of its improvement, than *OVERSTOCKING* it with cattle, ſo ſoon as it acquires a ſufficient ſolidity to bear them with ſafety; but care muſt be taken, not to put the cattle on it, until it is ſufficiently firm, otherwiſe the ſurface will be poached, and the coarſe herbage not cloſely bitten. Thus will the coarſe graſſes be cloſely eat down, and the preſſure of the cattle will help to conſolidate the ſurface. By this alone, it is wonderful to ſee the difference of verdure that ſoon takes place; and it is worthy of remark, that a bog of the worſt kind, after being drained and ſo treated, without any other melioration whatever, ſhould ſpontaneouſly produce ſo many

fine graſſes, that have hitherto lain dormant, and by the ſuperfluous moiſture been prevented from coming forth, ſhould, as it were all at once, be called into exiſtence, and afterwards continue to flouriſh and increaſe. The ruſhes will ſoon decline, and give way to better graſs, which will ſpring up in abundance. Lime, or marl ſpread on the ſurface, will greatly increaſe the growth of white clover, and other kinds of fine natural herbage, after the ruſhes and coarſe plants have been cloſely cut and eat down with the cattle *. The firſt thing, however, to be done, whether the field is to remain in the natural ſtate of paſture, or to be cultivated by tillage, is, to level the ſurface; the natural irregularity of which is, in moſt caſes, an obſtruction that ought firſt to be removed. The earth that compoſes the higheſt parts ſhould be removed, and mixed into a compound with lime, to be uſed either as a manure for a crop, or ſpread on the ſurface as a *TOP DRESSING* for graſs. Earth of inferior quality may be ſubſtituted for filling up the deepeſt hollows. Where the nature and ſituation anſwers, no improvement is ſo cheap, ſo ſure, or ſo profitable, as converting a certain claſs of bogs into water meadow †.

---

* THE beſt time to cut ruſhes, &c. is, when the ſhoots are weak, and before the ſeed comes to maturity. If left till the ſeed is ripe, it ſhakes, and falling on the ground, multiplies their growth. They ſhould be *FREQUENTLY* cut before this ſeaſon, which will ſoon extirpate them.

† IT muſt be underſtood, that the ſurface of the bog has been properly levelled,

If it lies along the ſide of a river or ſtream, of which, by means of proper dams and cuts, a command can be obtained; and if the proceſs of irrigation is managed with ſkill and attention, it never fails to produce luxuriant crops of graſs. This crop is in every reſpect beſt adapted to the nature of ſuch ground, being leſs affected by the inclemency of a cold or moiſt climate, and giving a more ſure return, without the labour and expence of annual culture, than any crop of grain that might be produced. As a proof of this, I ſhall only mention the water meadow on the eſtate of Odſtone Hall in Leiceſterſhire, which, from being mere bogs, before being drained by Mr. Elkington, now produce as abundant crops of graſs as any of the kind (water meadows) in that part of the kingdom. As a farther inſtance of the good effects produced by watering this kind of land, Mr. Boſwell, in his treatiſe on that ſubject, ſays, "Lands that are very boggy require more and longer watering than any ſand or gravelly ſoil: the larger the body of water that can be brought upon them the better; its weight and ſtrength will greatly aſſiſt in compreſſing the ſoil, and deſtroying the roots of the weeds that grow upon it; neither can the

---

well rolled, and a good ſward of graſs on it, before the operation of floating can be attempted. It is a fact well aſcertained, that in Merionethſhire there is land that was formerly not worth 6d. per acre; but being now *DRAINED AND FLOODED*, beſides affording excellent paſture till the 1ſt of June, produces two tons of good hay, cut in the beginning of Auguſt. *Agricultural Report of Merionethſhire.*

water be kept too long upon it, particularly in the winter ſeaſon, immediately after the *AFTERMEATH* is eaten, *AND THE CLOSER IT IS FED THE BETTER.* This ſpecies of ſoil, after being *WELL DRAINED* and watered, will equal the wiſhes of the moſt ſanguine by its improvement."

No general ſyſtem of irrigation can be properly laid down, applicable to every particular caſe, farther than ſome general directions that hold good in every ſituation. But, in other parts of the proceſs, different modes muſt be adopted, according as the ſituation and form of ſurface require. In thoſe where the command of a river or ſtream can be obtained, the general rule is, to collect a ſufficient quantity of water nearly on a level in a main carier, which can, by means of ſluices conſtructed at proper places in the ſides of it, be let out into floating trenches, cut along the ſurface of the field, or ſides of the declivity, one below another. Theſe floating trenches will collect the water from above, after paſſing over the ſpaces of ground betwixt each, and diſtribute it equally over the ſurface of each ſpace lying between them, alternately. Proper attention muſt be paid, at the proper ſeaſons, to open and cloſe the ſluices in regular rotation, ſo as to flood different portions of the land ſucceſſively, and the floating gutters ſhould frequently be cleaned and ſcoured out, to prevent their choking up, and to deſtroy the growth of ruſhes, or other graſs that may grow up in them. From the very abſorbent quality of the peat, the water would require to have a

more rapid motion on bogs, than on ſoils leſs porous or ſpongy. The ſaving of manure is another circumſtance in favour of water meadows, as the application of it would appear to be of no material conſequence, being very ſeldom uſed by ſome of the beſt flooders in England*. Still, however, I would think, that the uſe of lime or *SHELL* marl, diluted in the water of the upper carier, would be attended with the moſt beneficial effects. Its finer particles would thus be intimately diffuſed over the ſurface, would be lodged in cloſer contact with the roots of the graſs, and afford them additional nouriſhment to what they re-

* THE late celebrated Bakewell, who was a great advocate for watering, uſed no manure on his water meadows. It was a favourite idea of his, that water made to float over the greateſt bog or ſwamp, *WITHOUT BEING DRAINED*, would not only have the effect of producing a finer herbage on it, but that the preſſure of water artificially brought upon it, would force back that with which it was already overcharged into the channel from which it ſprung. Nothing can be more abſurd, and which the following fact will prove. At Drayton Park, near Tamworth in Staffordſhire, a conſiderable extent of bog was thus watered by a cut for that purpoſe, conducted under the direction of Mr. Bakewell at a very great expence, and which, after being completed, had the effect of rendering the ground much worſe and more ſwampy than before. This, to the ſurpriſe of Mr. Bakewell (but not entirely to his conviction), not having the effect which he argued it would, Mr. Elkington was applied to, who, by means of a drain which he made, and which did not exceed *ONE THIRD* of the expence of Mr. Bakewell's water works, has rendered the ground worth *TEN TIMES* its former value, and which now produces crops of grain equal in value to any that is produced in that county. This is mentioned as a proof, that land of that deſcription, without being previouſly drained, can never be watered with advantage.

ceive from the fertilizing qualities of the water. The operation would be ſimple, and the expence trifling, from the ſmall quantity of lime ſufficient for the purpoſe. The lime ſhould be laid down along the ſide of the uppermoſt trench or carier, and after being *SLACKED*, put in ſmall quantities among the water in the cut, and being ſtirred about, would be carried down by the ſtream, and equally diffuſed over the ſurface. It is to be obſerved, that the lime, or ſhell marl, is only to be uſed in this manner the laſt days of the watering. If there was not ſo heavy a duty upon it, the refuſe of ſalt uſed in this manner would be a valuable improvement, its fertilizing qualities being equally beneficial on paſture, as well as on arable land *. Theſe experiments I have never ſeen practiſed, although recommended; but it is obvious to every one who is in the leaſt acquainted with the manner of flooding, and with the qualities of theſe manures, that it muſt prove beneficial, beyond a doubt †.

* In a communication to the Board of Agriculture on the nature and qualities of ſalt as a manure, by Mr. Roalfe of Sandwich, he ſays, "Salt is alſo excellent upon ruſhy and ſour paſtures, which are ſubject to occaſion the rot in ſheep; ſuch is its effect, that it prevents that deſtructive evil from attacking them."

† A METHOD nearly ſimilar to this ſeems to be practiſed in watering ground in Switzerland, as appears from the following remark in a treatiſe entitled "Le Socrate Ruſtique," 1764. "Our cultivator conſiderably augments the vegetative properties of the water by *RICH MOULD*, procured, as I have already mentioned, from green turf cut from eminences in paſture or fallow land. This he throws into the

As it is only in certain ſituations, where this mode of improvement, by means of water, can be adopted and practiſed with advantage, I ſhall next take notice of the other means that may be uſed, and that are beſt calculated for the improvement of bogs, by converting them into a ſtate of cultivation, ſo ſoon after draining, as they become acceſſible to the ſpade or the plough.

If the bog is of conſiderable extent, the firſt thing to be done after draining, or which may be done at the ſame time, is, dividing it into proper encloſures by open ditches.

These will aſſiſt in carrying off the ſurface water, which the covered drains do not effect, and part of the earth thrown out of them may be mixed in a compound with dung and lime, or made uſe of in filling up ſome adjacent hollows. If the ground is to be pared and burnt, part of it may be burned along with the turf; but this is ſuppoſing that no thorns or quick fence is planted along the ditches, in which caſe no bank of earth is requiſite on either ſide. In ploughing, regard muſt be paid to the

---

principal head of water, ſo that the leſſer channels may imbibe and communicate fertility over the meadow." In a note by the tranſlator, alluding to this paſſage, he ſays, "This is a good thought, but the benefit on ſome ſoils of caſting *SLACKED LIME* into the ſtream, would be much greater, and acquired at a much leſs expence."

Although the watering of land is now arrived at a very great degree of perfection, yet theſe hints ſeem to have eſcaped the attention of moſt practical flooders.

proper direction and inclination of the ridges and furrows towards the open ditches, in order to diſcharge the rain water as it falls *. The great object is, to get the ground brought to ſuch a ſtate as to be fit for being laid down with graſs ſeeds, when it may be conſidered in ſuch a ſtate of improvement, that any ſubſequent crops will require no more than ordinary management to cultivate.

In levelling or ſmoothing the ſurface, it will be neceſſary to uſe the ſpade, by which the work will be done nearly as expeditiouſly, and much more effectually, than with the plough at firſt. There are various opinions, how far paring and burning is conducive to the improvement of land. Some have condemned it, as a practice that ought to be exploded *ON EVERY*

* Some bogs, when *TOO MUCH DRAINED*, are apt to become parched in dry ſeaſons. To remedy this, if the ground is very flat or nearly level, ſluices may be made in the lower end of the diviſion ditches, which, in very dry ſeaſons, may be let down to keep in the water received from the top drains. If the ditches have a deſcent, ſo that the water cannot ſtand level all the way, ſeveral ſluices of this kind will be neceſſary, or the water may be ſtopped by building in turfs. The water may be allowed to ſtand within a foot, or a foot and a half of the ſurface; and by its ſtagnation, will ooze through the peat or upper ſoil, and afford ſuch a degree of moiſture as will greatly relieve the crop. If in paſture, the cattle ſhould not be allowed to feed on it while the water remains in the ditches, nor for ſome days after, as they would *POACH* the ſurface too much, and the heat would make them go into the ditches, where they might not eaſily get out.

SOIL; yet, on a certain claſs of boggy ground, it may be conſidered as a very great improvement, not only from the excellent manure that the aſhes produce, but alſo from its deſtroying the roots of every noxious plant more effectually than could be done by means of fallowing alone. The aſhes of the burnt turf, when mixed with the ſoil by a ſuperficial ploughing, ſo enrich it as to produce excellent crops for two years at leaſt; and if a little lime is added, it will help ſooner to pulverize and heat the ſoil. If the bog is covered with long heath or ling, and other coarſe *BENTY GRASS*, it might be proper to burn it *GROWING*, without paring off any part of the ſoil; but this would yield only a ſmall quantity of aſhes, neither would it deſtroy entirely the roots of the plants; and when ploughed in, would produce very little effect. So ſoon as the turfs are reduced to aſhes *, they ſhould be equally ſpread over the ſurface, ploughed in with a light furrow, and turnip or potatoes ought to be the firſt crop. If the former, they ſhould be ſown *BROADCAST*, and fed off with

* In burning the turfs after they are properly dried, they ſhould be ſet up in *LARGE HEAPS*, adding to them as they burn. This confines the ſmoke and flame, by which ſo much of the eſſence is evaporated and loſt, when the turfs are burnt in ſmall heaps.

PARING and burning the turf is, in ſome places, begun in the month of March; but it is better to delay the burning till April or May. The paring, however, may be done in March, and the turfs will be dry enough for burning in the month following.

ſheep. By this the ſoil will receive great benefit, from the dung and urine, the refuſe of the plants, and by being conſolidated by the trampling of the ſheep. It will then be in good ſtate for a crop of oats or barley, which ſhould be ſown with graſs ſeeds, well rolled down. The ploughing after the turnips are ate off, ſhould be very ſlight, not to bury the ſheeps dung, &c. too deep; in which caſe a crop of oats is preferable to barley, as the preparation of the ground requires leſs ploughing. If the ſoil is full of the roots of ruſhes, and other weeds, a courſe of ſummer fallow will be requiſite before any crop is taken; and if the aſhes have been made in one corner of the field, they can be ſpread over the ſurface before the ſeed furrow is given; and the roots and tough clods may be collected into heaps, burnt, and ſpread along with them.

If the bog is deep of peat, and very ſoft, ſo as not to be fit to carry horſes for ploughing it the firſt year, a crop of *TURNIP BROADCAST* may be got, by ſowing the ſeed among the ſpread aſhes, harrowing it in with a light harrow and roller, drawn by men. The turnip ſhould be eat off with ſheep, and the ground will next year be ſo much conſolidated, as to admit the plough.

If the ſurface is not pared and burnt at all, a courſe of fallow, even for two years, will be neceſſary to reduce the ſoil to a proper mould; in the laſt ſtage of which, the lime or other manure may be applied. In this caſe, two white crops, with an inter-

vening one of turnip, potatoes, &c., may be taken before the graſs ſeeds are ſown *. All boggy ſoil whatever, after being once broke up and pulverized by tillage, and a courſe of ſummer fallow, ſhould not be overcropped before being laid down in graſs; and when once brought into a good *SWARD* of graſs, ſhould not be too ſoon broke up, but continue ſo, bruſh-harrow-

* RYE being a hardy grain, and thriving on very poor ſoils, is a very profitable crop on *DRAINED BOGGY LAND PARED AND BURNT*, as appears from the following extract of a communication to the Board of Agriculture, reſpecting the ſtate of huſbandry in the neighbourhood of Peterſburgh. "Rye bread, as every body knows, is the chief ſupport of this diſtrict, as well as of the other northern parts of Ruſſia; but in order to ſave the rye flour, and to make it laſt the longer, the inhabitants, when compelled by neceſſity, mix with it *FINE GROUND OATMEAL*, the meal of buck wheat, and the huſks of the field muſtard ſeed (*ſinapis arvenſis*). The produce of rye, in very few places, varies more than here. The poor ſandy lands will hardly produce more than three times the quantity ſown. The middling ſorts of land produce four and ſix times the ſeed. The rich and well manured lands, and ſuch where wood has been cleared off, will produce, in a good ſeaſon, ten or twelve for one ſown; but, the moſt extraordinary produced, is gathered from *BOGGY LANDS DRAINED* and ſown with rye, as in a favourable ſeaſon it increaſes forty times and upwards. The reaſon of this extraordinary increaſe muſt be explained. It is owing to the aſhes produced *BY BURNING THE BOGS*, which aſſiſt the vegetation to that degree, that frequently they find one grain produce forty plants, and even more. For this reaſon, they generally uſe a much ſmaller quantity of ſeed in ſowing ſuch land. There is no need to ſow clump rye (*ſecale multicaule*) upon ſuch lands, as any good common ſeed increaſes very much upon ſo rich a ſoil, to which the burning of the ſurface has added ſo much of the vegetative power. The ſeed is ſown in July or Auguſt, and is reaped about twelve months after."

ing and top dreſſing it, when the herbage begins to fog. Frequent rolling is alſo very neceſſary in ſuch ſoft ſoils.

It is better to feed ſheep the firſt and ſecond years of the graſs, than to cut it for hay, as it cauſes the roots of the plants to ſtrike more horizontally through the ſoil, and more cloſely cover the ſurface. For this purpoſe a greater proportion of white and yellow clover, and other *SHORT GRASS* ſeeds, ſhould be ſown. In the ſecond breaking up of the ground, after lying ſome years in paſture, no particular mode of practice or rotation of cropping can be laid down; the ſtate of the ground then muſt be the rule for after management, and by which time it will not only have attained a firmer texture, but alſo a degree of ſtrength to produce any crops, with proper manure and cultivation. In manuring ſoft boggy ſoils, one precaution is neceſſary. The deeper the ploughings are, previous to the dung being laid on, the better; but the ſubſequent furrows ſhould be very ſuperficial, and the dung intimately mixed; for when it is ploughed in too deep, not equally diſtributed and incorporated with the ſoil, it is apt to ſubſide below reach of the plough, or horizontal roots of the grain. The ſame is the caſe with lime, which always penetrates deeper into the ſoil; and marl, when buried too deep, loſes all its effect *.

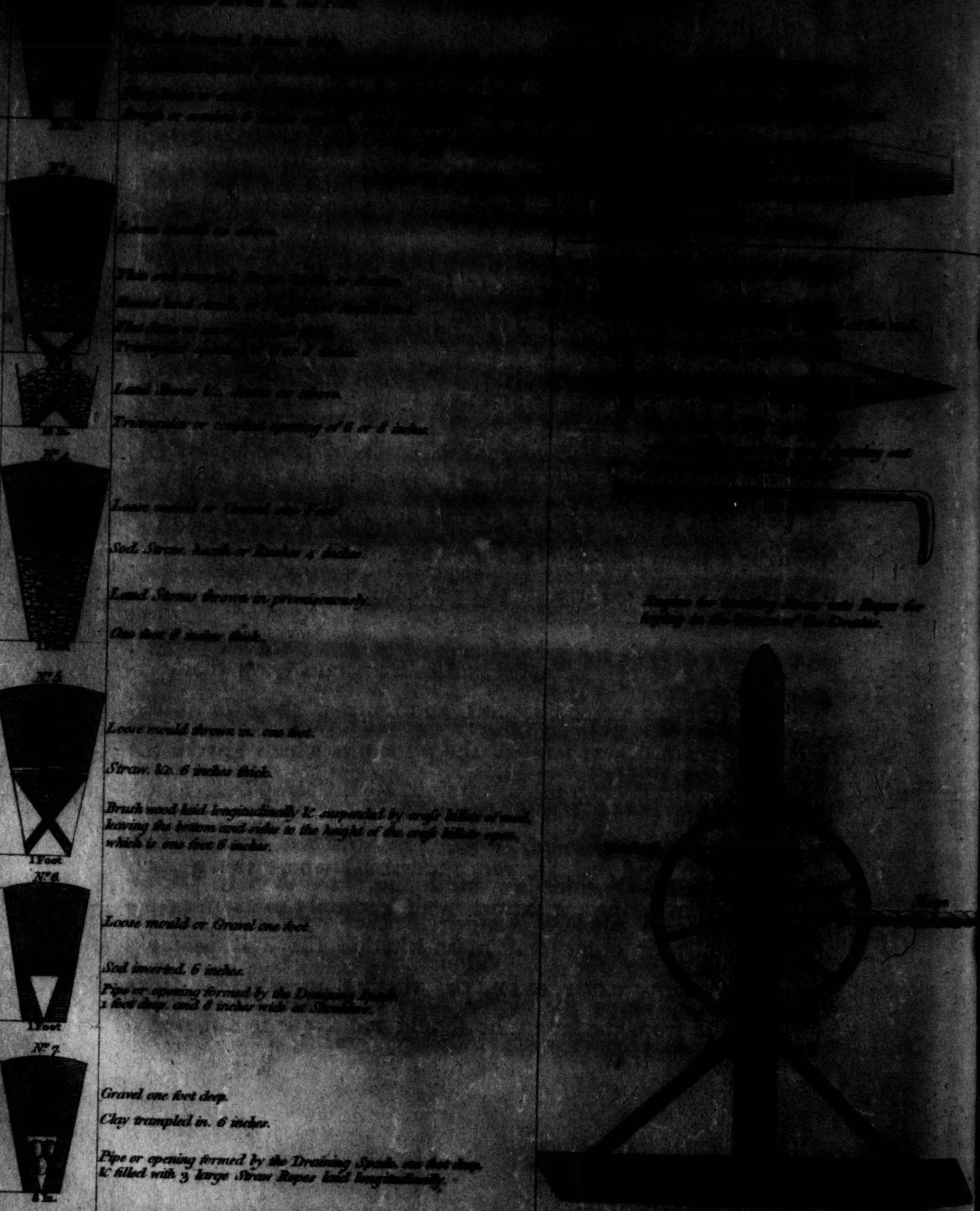
* COAL aſhes is an excellent manure for ſour wet land.

Upon ſoft boggy land, intended only for paſture, nothing will work a more quick improvement, than covering it with a thin ſtratum of clay, gravel, or any other earth, heavier than that of which the bog is compoſed. Clay marl, where it can be got, is of all others to be preferred, both on account of its greater weight and enriching qualities. Sea ſand, being mixed with ſhells, is peculiarly adapted for this purpoſe, if the bog is ſituated near the ſea, where ſuch can be eaſily got. The weight and preſſure of theſe heavier bodies makes the bog ſoon become more ſolid, and likewiſe preſſes out more quickly the moiſture contained in the ſpongy peat. The thicker, therefore, it is laid on, the better. A thin ſprinkling of lime over it will add to its effect, and cauſe white clover and other ſweet graſſes to ſpring up in greater abundance. The moſt barren ſoil will have a good effect when uſed in this manner; but of all others, limeſtone gravel is preferable. By means of it, many extenſive bogs are improved in Ireland, where it abounds; but very little of it is found either in England or Scotland, which renders that mode of improvement impracticable. After the ground has been thus treated, and lain ſome years in paſture, it may be broke up by tillage, and crops of grain taken, before being laid down with *GRASS SEEDS*. By ploughing it, part of the natural ſoil will be turned up, and intimately mixed with the earth, &c. that has been laid upon it, and if lime or dung is added, will altogether form a very fertile mould.

SUCH are the methods by which many bogs have been cultivated and improved after draining, in ſeveral parts of England, the ſucceſs of which is a ſufficient recommendation of the practice. But *THESE HINTS* are not to be conſidered the only means whereby this improvement can be effected; there are others equally beneficial, and, in many ſituations, equally applicable, by means of which there is no doubt that much *BOGGY GROUND*, however barren in its natural ſtate, may ſoon be rendered highly productive. But, to enumerate theſe would be unneceſſary; for every one who poſſeſſes ground of this deſcription will be able to aſcertain what mode of management is beſt calculated for its ſituation, what crops he wiſhes to raiſe, or what kinds of manure he has in his power to apply.

SECTIONS of different kinds of Drains

Parents Upper Soil	N° 1	Loose mould or clay.
Sand or Gravel		Land Stones thrown in promiscuously.
Clay		One foot 6 inches thick.
Parents Upper Soil	N° 2	Loose mould or clay.
Sand or Gravel		Thin sod inverted, or Straw, heath or Bushes.
Clay		Round land stones of a moderate size.
		Triangular opening of 6 or 8 inches.
Sand or Gravel	N° 3	Land Stones &c. thrown in promiscuously.
Clay		Triangular or coupled opening of 6 or 8 inches.
Clay &c.	N° 4	Loose mould or Gravel one foot.
		Sod, Straw, heath or Bushes 4 inches.
		Land Stones thrown in promiscuously.
		One foot 6 inches thick.
Clay &c.	N° 5	Loose mould thrown in. one foot.
		Straw, &c. 6 inches thick.
		Brush wood laid longitudinally & suspended by crafs billets of wood, leaving the bottom and sides to the height of the craft billets open, which is one foot 6 inches.
Clay &c.	N° 6	Loose mould or Gravel one foot.
		Sod inverted, 6 inches.
		Pipe or opening formed by the Draining Spade 1 foot deep, and 8 inches wide at Shoulder.
Gravel or Porous Soil	N° 7	Gravel one foot deep.
Clay		Clay trampled in. 6 inches.
		Pipe or opening formed by the Draining Spade, one foot deep & filled with 3 large Straw Ropes laid longitudinally.



The depth of the above Drains, is mostly 3 feet, but where the nature of the Soil may admit, the depth may be less, as the circumstances

APPENDIX,

PART II.

On Hollow and Surface Draining in General, drawn up from Communications tranſmitted to the Board of Agriculture.

THIS being a part of the draining ſyſtem, not coming within the limits of Mr. Elkington's practice, and founded on principles different from thoſe that are applicable to the drainage of bogs and other ſwampy ground injured by ſprings, I have thought it more proper to add it as part of the Appendix, than to have incorporated it with the preceding Report.

WHEN the wetneſs of a field ariſes from rain water that cannot ſink through a tenacious ſoil, and muſt, if there is no declivity, remain till evaporated, the principles which govern the practice of Mr. Elkington's art are not applicable. But,

IN all caſes (and ſuch are very numerous) where the wetneſs proceeds from ſprings, a farmer ought certainly to examine his field carefully, in order to aſcertain whether the evil proceeds from the *ABOVE CAUSE ONLY*, or whether it proceeds from ſprings. If from the latter, he ſhould endeavour to diſcover if

ſuch ſprings are diſtinct and unconnected, or whether they do not flow from ſome *MAIN ONE*, which being cut off, would drain a conſiderable tract of land below the ſpot where it riſes, as has been explained and exemplified in the latter part of Chap. III.

FROM want of due attention to this neceſſary diſcrimination, it is very common in Eſſex, Suffolk, and other counties where draining is very generally performed, to ſee many ſuperfluous drains marked out, in directions where they can have very little effect, and where a ſingle one, well directed, would have completely dried the field. As the expence which might thus be ſaved is an object of conſequence, too much attention cannot be paid to the inquiry.

SECT. I.

Of the Antiquity of the Practice of Hollow Draining.

THAT the Romans were not unacquainted with moſt of the modern methods of hollow draining, appears from all their writers *de re ruſtica*. Cato, Palladius, Columella, and Pliny, mention them particularly, and deſcribe ſome circumſtances which have lately been conſidered as modern improvements. Upon ſtrong tenacious land, where the water could only be received at top, they preferred open drains; on other ſoils,

where the water could be drawn equally from both ſides, or could riſe from the bottom, they uſed covered ones. They knew the propriety of directing them obliquely acroſs the ſlope of the field, a point in which modern drainers are often erroneous. Their general depth was from three to four feet, filled half way up with ſmall ſtones; for want of theſe with willow poles, and even with the ſpray of wood twiſted into a rope, one of the lateſt practices with ſtraw that has taken place in England. Of that material alſo, the Roman farmers availed themſelves when others were wanting. The ends of their drains they were careful in fortifying with larger ſtones in form of bridges, and the mouths or outlets were laid in maſonry; a circumſtance in which Mr. Whyn Baker of Ireland thought himſelf original.

From the depth, it appears that their drains were deſigned to carry off the water of ſprings as well as that cauſed by rain on a flat or retentive ſurface ſoil, for both which they were, in ſome caſes, equally well adapted *.

To the proper direction of the water furrows, in order to convey all ſurface water into the drains, and to the clearing

* The paſſages of the ancient writers on this ſubject are quoted and tranſlated by Mr. Dickſon in his "Huſbandry of the Ancients," Vol. I. p. 358, where the reader may ſee the details at large.

and cleaning out of the ditches round the fields, they paid particular attention. Theſe circumſtances are ſufficient to prove that the Romans underſtood the buſineſs of common draining in great perfection, and that our beſt cultivated counties had little to boaſt of in this reſpect, in ſuperiority to the ancients, till Mr. Elkington made the diſcovery of a method with which they were wholly unacquainted. The beſt of the French writers on agriculture, De Serves, who wrote in 1600 his *Theatre d'Agriculture*, deſcribes hollow drains particularly: they were filled with ſtones.

SECT. II.

When firſt uſed in England.

It would demand a very careful peruſal of all the earlier writers on huſbandry to aſcertain when this practice was firſt introduced; but a circumſtance occurred in Suſſex, which ſhows that hollow draining was in uſe long before any mention would be found of it, were ſuch authors conſulted, as no notice of it occurs either in Fitzherbert or Norden. In 1770, Mr. Poole of that county informed a farming traveller, "That near one hundred years ago, a very large oak, two hundred years old, was cut down at Hook. In digging a ditch through the ſpot where the old ſtump was, on taking up the remains of it a

drain was diſcovered under it, filled with alder branches; and it is remarkable that the alder was perfectly ſound, the greenneſs of the bark was preſerved, and even ſome leaves were found. On taking them out, they preſently dropped to powder. It is hence very evident, that underground draining was practiſed three hundred years ago in this kingdom. We find alſo, that alder is, of all other wood, the beſt for filling drains. Probably no other, except aquatics, would endure nearly ſo long. Buſhes are generally uſed, but ſallow or willow probably better *."

THE board of Agriculture has been informed by Richard Preſton, Eſq. one of its correſpondents, that land draining, according to the preſent practice, is not of more than forty years ſtanding in his neighbourhood in Eſſex.

THIS deſerves inquiry; for it is generally ſuppoſed to have been uſed there long before ſuch a period.

* Eaſtern Tour, Vol. III. p. 141.

SECT. III.

Nature of the Moiſture or Wetneſs againſt which they are chiefly uſed.

SPRINGS that proceed from water at any conſiderable depth in the earth, or which break out, from the variation of certain ſtrata, in hills, which demand deep cutting and the uſe of the auger to work their cure, according to Mr. Elkington's mode of draining, has already been treated of. Hollow drains that come under the preſent deſcription, are chiefly uſed to correct that wetneſs of ſoil which reſults from rain, and which, from flatneſs of ſurface, or its retentive quality, ſtagnates, to the injury of both ſoil and crops. This is the moſt general nature of the evil which theſe drains are intended to remedy, but by no means excluſively of that cauſed by *LAND* ſprings, whoſe ſeat apparently is not below their depth. The wetneſs proceeding from ſuch, is, in ſome caſes, removed by theſe drains, when deep enough cut and properly directed; but in many others, from ignorance in the drainer, great ſums of money are thrown away, for want of attending properly to the nature of the evil, and of diſtinguiſhing betwixt *SURFACE WATER ONLY*, and the oozing of *LAND SPRINGS*.

SECT. IV.

Of the Soils on which they act, and of thoſe on which they have been found to fail.

IN ſoils that are ſo tenacious as to retain water on the ſurface till evaporation carries it off, ſuch as are found in Suſſex, Surry, and in many other counties, this method of draining has been tried and found entirely to fail. The cauſe of this can eaſily be accounted for. Very ſtiff clay will hold water *LIKE A DISH* (the expreſſion of the farmers in thoſe counties who have attempted to drain ſuch ſoil), and conſequently the ſmall portion of water which each drain will carry off, is only what falls immediately above it, or what it can receive at top, when the ground on each ſide has a deſcent towards it.

THE water being all *ON THE SURFACE*, cannot find its way into them. If they are on a declivity, the water will run over them, as it does over any other part of the field; and if they are in a hollow, it will ſtagnate even above them, and will be moſtly exhaled before any quantity of it ſubſides into them. This is therefore a more expenſive ſoil to drain, requiring a greater number of trenches, and theſe very cloſe together, than any other ſoil whatever. Open trenches, with the ridges and

water furrows properly formed and directed, is the only method whereby its drainage can be effectually accompliſhed.

It is neceſſary to lay it up in ridges properly placed, and to cut *SMALL OPEN DRAINS* acroſs the ridges where requiſite, communicating with each other, and with the furrows; and thus all the water furrows operate as drains. The water, as it falls upon the ridge, immediately makes its way into the furrows, and runs along them, while there is deſcent; and if it is ſtopped in any of them by the ground riſing, is conveyed by the drains acroſs the ridges into ſome other furrow where there is a deſcent, along which it marks its way into ſome ditch or water courſe, at the extremity of the field.

In Eſſex, and in Suffolk, where it has been found advantageous, the ſoil is a wet poachy loam, more or leſs mixed on the ſurface with vegetable mould; under that, in ſome places, a *RAW HUNGRY LOAM*, and in others a clay marl.

On theſe ſoils the effect is very great; for the upper ſtratum, where the moiſture is chiefly lodged, being in ſome degree porous, the water is eaſily extracted from it by means of the drains. The under ſtratum being alſo of a retentive quality, their depth does not require to be great.

When Mr. Young of Clare, who has had great experience in

this mode of hollow draining, obſerves, that the improvement by theſe drains is great on clay ſoils, he certainly means ſoils of this deſcription. "I know from experience, that in clayey ſoils it will anſwer perfectly; that it is the leaſt expenſive and the moſt expeditious, as well as moſt durable improvement, of any in the whole ſyſtem of agricultural economy. This will be further treated of in Sect. XVIII.

SECT. V.

By what Rules their Direction is marked.

For many years, probably for more than half a century, and poſſibly during a much longer period, the farmers did not make a proper diſtinction in fields that had a declivity, between tracing their drains *WITH THE SLOPE*, or directing them *OBLIQUELY ACROSS IT*. Large tracts have been drained, or have been meant to be drained, in the former way, and many, even to this day, are guilty of the ſame error; but the beſt farmers are now attentive to ſo important a point, and ſtudiouſly mark the direction of their drains obliquely. They are alſo careful to give them juſt the fall ſufficient to carry off the water in a gentle and not a rapid current, by which means they are leſs apt to choke, or *BLOW UP*, as it is ſometimes called, whereby ſpots in the field have apparently an artificial ſpring formed.

Upon fields, level, or nearly ſo, great numbers of which are found in the weſtern counties of England, it has been a common practice, and not an improper one, if the wetneſs proceeds ſolely from rain, to mark the drains regularly at a rod *, a rod and half, or two rods aſunder, acroſs the land from ditch to ditch; or if the drains, from any ſmall inequality of ſurface, will flow only at one end, then to ſtop ſhort or diſcontinue their length on one ſide of the field, as ſoon as the ditch operates in laying it dry.

Where the ſlopes of a field vary, and fall in different directions, the farmer ſhould attend to ſuch variations, and direct his drains ſo as to croſs obliquely the upper ſide of each declivity.

It is a general rule, not to conduct too many drains to the ſame mouth or outlet; for if much water flows in any drain, from having thrown many lateral branches into one main drain, the latter muſt not only be made larger and deeper, but will even then be liable to fail; and a failure in that caſe affects ſo much a larger ſpace of ground, by impeding the courſe of ſo many other drains. On this account it has been found better to make the drains detached, rather than to connect too many of them together, which occaſions much water to be conducted to one mouth.

* Sixteen and a half feet.

Cases will however occur, in which, from the poſition of the ground, it may be found neceſſary to join ſeveral ſide branches (wings) into one main drain. On this ſubject, Mr. Vancouver, in his Agricultural Report of Eſſex, has the following judicious remark.

"If the field propoſed to be drained lies greatly upon the deſcent, every care ſhould be taken to make the drains bear ſufficiently horizontally, in the firſt place, to prevent a too precipitant fall of the water, by which the bottoms of the drains would be worn uneven, and a temporary obſtruction occaſion them *to blow*; and, ſecondly, becauſe the more perfectly horizontal is the field, ſo that it lies level free, and affords a ſufficient fall for the water, the leſs occaſion will there be for the ſame number of drains as would be required upon a ſoil of equal cloſeneſs upon the ſide of a hill. The drains in the field that lies nearly level, drawing equally well upon each ſide; whereas thoſe on the hang of a hill, drawing only from the higher ſides of the drains, and conſequently requiring them to be made much nearer or cloſer together."

SECT. VI.

Seaſon for executing the Work.

On this point opinions vary; ſome preferring winter, and others ſummer.

When a great quantity of work is to be done, all ſeaſons of the year free from ſharp froſts muſt be made uſe of; and this is uſually the caſe, when a farmer enters on a leaſe to a farm which has not been drained, or which requires to be done a ſecond time. Stubbles are done in winter, and fallows in ſummer; but when a ſingle field or two are only to be done, the farmer may chooſe the moſt convenient ſeaſon. Many excellent farmers would not do it at any other time than ſummer, from being then able to execute the cuts in a cleaner and neater manner, and free from that kneading and plaſtering which takes place in winter, and which, they think, tends to prevent the flowing of the water from thoſe minute and imperceptible veins and interſtices of the ſoil through which the water percolates. They have farther remarked, that opening the earth in a dry ſeaſon gives a tendency to drain it, as the particles of the ſoil, after being ſeparated and well dried, will not ſo eaſily unite again; whereas the kneading in winter tends to increaſe tenacity where it is moſt to be avoided. Farther, that carting

on the fields in winter, to bring on ſtones or other materials, is more difficult and dangerous than in ſummer.

In oppoſition, however, to theſe ideas, Mr. Young of Clare in Suffolk is of a contrary opinion.

"I never land-drain (ſays he) in ſummer: Two inconveniencies attend it; the increaſe of labour in a clayey ſoil, when hard and dry, is very conſiderable, and the want of leiſure, and when good labourers are ſcarce."

The want of labourers, in ſome places, may be an unanſwerable objection, but the dryneſs is not; for, if the previous furrows opened by the plough, or laſt courſe of ploughing on arable land, be not left to dry, but the ſpades follow directly, after a little rain, there will be moiſture ſufficient to make it work freely. Many good drainers prefer executing the work when the land is under *A LAYER*, *i. e.* ſown down with graſs. Lord Petre, on this, obſerves, that the plough for opening the previous furrows works better on a layer.

"I PREFER a lay, if layed down level, as I have a plough on a very ſimple conſtruction, with which, and ſix horſes, I can plough from ten to twelve inches deep, and lay the furrows as regular as a man can with a ſpade; ſo that, after the ditch is digged and filled, the furrow can be put into its place again,

and rolled with a large roller quite level; and then I dig but one *SPIT* with the bottom land ditching ſpade, fourteen inches deep. The expence 2s. 8d. per 20 rod, the digger returning the furrow to its place. I alſo uſe this plough on fallow; but it does not anſwer ſo well, as the moulds fall into the furrows. The expence of digging on fallow is 1s. 2d. per rod."

WHEN the ground is in ſummer fallow, is certainly the beſt time for caſting drains that are only for carrying off ſurface water, as the diſtinctions betwixt the wet and dry parts of the field is then eaſily perceptible, and any prominent inequalities of ſurface may then be more eaſily levelled or reduced, by paring off the heights, and adding to the hollows.

SECT. VII.

Manner in which Drains are partly opened by the Plough.

THE method practiſed by Mr. James Young of Clare, which he has deſcribed himſelf, from very ample practice, is deſerving of attention. He ſays, "When I have marked the drains in a field (uſually a rod aſunder), I draw two furrows with a common foot plough, leaving a *BAULK* betwixt them about fifteen inches wide; then, with a ſtrong double breaſted plough, made on purpoſe, I ſplit that *BAULK*, and leave a clean furrow fourteen

of fifteen inches below the ſurface; but, where the depth of ſoil requires it (for I like to touch the clay), by a ſecond ploughing I ſink it to eighteen or twenty inches; it is then ready for the land-ditching ſpade, with which I dig fifteen inches deep, a drain as narrow as poſſible *."

THE method followed by ſome good farmers, who do not poſſeſs ploughs made on purpoſe for the work, is this: With their common plough, drawn by four or five horſes, and uſually ſtirring about four or five inches deep, they turn a double furrow, throwing the earth on each ſide, and leaving a *BAULK* in the middle. This *BAULK* they raiſe by a ſecond *BOUT* in the ſame manner; then they go in the open furrow twice with their common double breaſt plough, getting what depth they can; after this, they ſhovel out all the looſe mould and inequalities, to the breadth of about a foot, and thus having gained a clear open furrow, the depth varying according to the ſoil and ploughs, but uſually about eight or nine inches, they dig one *SPIT* with a draining ſpade, ſixteen inches deep; thus gaining in the whole twenty-four or twenty-five inches. But, as this depth is ſeldom ſufficient, when neceſſary they throw out another, or even two other *SPITS*, which makes the whole depth from thirty to forty inches.

* Annals of Agriculture, vol. viii. p. 164.

SECT. VIII.

Depth and Width.

THE depth is various, according to the nature of ſoil, the ſituation of the field, the expence the farmer is willing to incur, and to a diverſity of other circumſtances. Many years ago, three feet was the common depth in moſt ſoils; but, for twenty years paſt, they have ſeldom exceeded thirty or thirty-two inches; and the number that are cut only twenty-four or twenty-ſix, much more conſiderable.

MAIN or receiving drains are always a little deeper than the others, having more water to convey, and farther to carry it. The deeper they are dug in pervious ſoils, the farther they will operate in reducing the moiſture to a level, where it can leſs injure vegetation; but, when the ſpade reaches an impervious ſoil, through which water will not percolate, there is no occaſion for making the trench any deeper. A few inches, however, in the clay, as a ſafer channel for the water, is of advantage.

ONE general rule is never to be departed from, which is, that the depth muſt be ſufficient to prevent the impreſſion of the feet of cattle from affecting the poſition of the materials uſed in

filling them. This muſt particularly be obſerved of horſes walking in the furrow while ploughing, as they then tread four inches, and perhaps more, below the ſurface of the ground; add to theſe four inches, nine or ten more for the materials, and when the drains are only twenty-four deep, there will be nine or ten inches of ſoil to bear the weight of the horſe in the act of ploughing. This, as the earth has been ſtirred, ſeems certainly too little, and ſhould apparently aſcertain that twenty-four inches is by no means a ſufficient depth. If, by going thirty inches down, a tenacious ſoil is not too deeply entered, a greater depth in a more porous one is not only requiſite, but ought to be greatly preferable.

In all the modern drainages in the eaſtern counties, the farmers have been very ſolicitous to cut them as narrow as poſſible; by which means a great ſaving is made in the materials uſed for filling them, ſuch as buſhes, poles, ſpray, or ſtraw; but if brick or ſtones are uſed, of courſe this rule cannot be adhered to. However, there is no occaſion for the width being greater than one foot, if the ſtones are only coupled at bottom, or thrown in promiſcuouſly, or more than ſixteen inches if laid in the form of a conduit. Whatever the depth of materials be, the mould that covers them to the ſurface ſhould never be leſs than one foot thick, or rather more, in all tillage fields. In paſture land, gravel if at hand (eſpecially if the ſoil

is very tenacious), is preferable to the mould thrown out, which may be ſpread in any adjoining hollow.

THE depth and width, &c. marked in the Plate, is the proportion that ought to be adopted on all land that is wet from ſurface water, or from its ſtagnation in a porous upper ſoil.

SECT. IX.

Tools Employed.

THE inſtruments which have been long in common uſe in the eaſtern parts of the kingdom, are extremely ſimple.

WHILE the depths of the drains were more conſiderable than at preſent, three ſpades were in uſe to ſucceed one another, leſſening in breadth gradually, in ſuch a manner as to form a regular contraction to the bottom; but of late years, cheaper and eaſier methods have been purſued. By previous ploughing, all the ſpades except the lower one, have been laid aſide; and where a greater depth than common has been required, not more than two have been uſed. The ſcoop, which is puſhed or drawn along the bottom of the drain, to clear out the looſe moulds and prepare it for the materials uſed in filling, varies, in ſize and breadth, according to the width of the drain.

The draining ſpade, which is alſo of different ſizes, is repreſented in the Plate.

SECT. X.

Of Digging Hollow Drains.

The preceding circumſtances point out the manner in which theſe drains are, for the moſt part, dug; but there is a material difference in the truth and accuracy with which they are executed, according as a workman is accuſtomed to the buſineſs, and ſkilful or awkward in handling his tools. The work is almoſt univerſally done by meaſure, at ſo much a ſcore rods, which, as in ſimilar caſes, induces the men to earn as much as poſſible. They require, however, cloſe attention to ſee if they keep to the depth contracted for, and that they depoſite the earth ſo as not to fall in, in the act of filling, eſpecially as the ſurface ſoil ſhould (on one ſide at leaſt) be kept free from the clay or lower ſtratum.

In filling, more attention is neceſſary, if done by contract, which will be afterwards explained.

SECT. XI.

Opening Drains by the Plough only, &c.

THE Society for the Encouragement of Arts, Manufactures, and Commerce, gave a bounty, about 20 years ago, to Mr. Makins of Suffolk, for having invented a plough to cut hollow drains.

THERE was merit in the idea, but it has long ſince been entirely laid aſide both in Suffolk and Eſſex*.

ANOTHER plough, to anſwer the ſame purpoſe, was invented by Mr. Arbuthnot of Mitcham, of which an account is given in the "Eaſtern Tour," with a plate and meaſurement of it. And lately, the Society of Arts have made ſeveral trials with a plough for the ſame purpoſe, called a *MINER*, of a ſingular conſtruction; the intention of which is, by conſiderable force, to draw a pointed circular iron, at a given depth, through the earth, which ſhall form a pipe in it, not to be filled with any materials; but in the expectation, as it is ſaid from experience,

* IN Bailey's Advancement of Arts there is a plate and explanation of it, p. 6.

that the water will flow freely through the ſoil it has looſened*. As the Society has not yet finiſhed their deliberations on this inſtrument, it is not proper to offer any remarks on it.

It is imprudent too readily to ſuppoſe a limit to human invention; but it may be obſerved, that the probability of an *EFFECTIVE HOLLOW DRAINING PLOUGH* being invented, that ſhall work ſo much cheaper than the ſpade, as to become an object of economy, is not flattering: None hitherto tried ſeem fully to anſwer this idea; but there can be no difficulty in making one to prepare for the narrow drain-ſpade, to take one *SPIT* at bottom. The repeated ploughings or ſhovellings with common tools are expenſive, and might probably be executed in a cheaper and more expeditious manner by an open drain plough.

---

* The following deſcription of the *MINER* is given in the Agricultural Survey of Lancaſhire:

"Another inſtrument has been lately introduced, which Mr. Eccleſton, with propriety, calls the *MINER*; which is a ploughſhare fixed in a ſtrong beam, without mould-boards, and drawn by four or more horſes, and follows in the furrow the plough has juſt made, and, without turning up the ſubſtratum, penetrates into, and looſens, from eight to twelve inches deeper than the plough had gone before; which operation, beſides draining the land, cauſes the water to carry along with it any vitriolic, or other noxious matter, by the ſubſtratum being thus looſened; the roots of plants may penetrate the deeper; and, in courſe of time, that which is but a barren ſubſtance may become fertile ſoil. The expence of the operation is very inconſiderable."

How far that invented by Mr. Knowles, and rewarded by the Society of Arts, would at a ſufficiently cheap rate anſwer this purpoſe, has not been ſufficiently aſcertained. But it is obvious that, from the force and number of horſes or oxen requiſite to work them, ploughs calculated for this purpoſe will never come into general uſe.

ANOTHER invention for draining land, in Eſſex, is thus deſcribed in the Agricultural Report of that County: "The author of this experiment has conſtructed, and uſes a draining wheel of caſt iron, that weighs about 4 cwt.; it is 4 feet in diameter; the cutting edge, or extreme circumference of the wheel, is half an inch thick, which increaſes in thickneſs towards the nave or centre, will, at 15 inches deep, ſcore out or cut a drain half an inch wide at the bottom, and 4 inches wide at the top. This wheel is ſo placed in a frame, that it may be loaded at pleaſure, and be made to operate to a greater or leſs depth, according to the reſiſtance made by the ground; which thus ſcored out in the winter, the wheel tracts are then either filled with ſtraw ropes, and lightly covered over, or left to crack wider and deeper during the enſuing ſummer. The fiſſures are then filled with twiſted ſtraw or buſhes, and covered lightly with ſome of the moſt porous earth that may be moſt conveniently at hand; and thus upon the graſs, or ley land, are hollow drains formed at little or no expence, and which, upon trial, have been found to anſwer extremely well."

This draining wheel is alſo deſcribed in the Annals of Agriculture, where it is ſaid, that twelve acres have been done with it in one day; but neither the expence of the machine, nor number of horſes required to draw it, has been ſtated. It works or cuts beſt, when the land is wet and ſoft.

On lawns and ſmooth paſtures, where heavy cattle are not admitted, and on which, from flatneſs of ſurface, and retentive quality of ſoil, every rain ſhower will ſtagnate, it may prove of ſome utility, even although the ſmall *GRIPS* made by it are left open, or filled with looſe gravel.

SECT. XII.

Materials with which they are filled.

In reſpect to the materials for filling the drains, the farmer muſt be guided by circumſtances of ſituation, &c. Thoſe moſt commonly uſed, are, 1. ſtone, 2. wood, 3. ſtraw and ſtubble, 4. heath or ling, and 5. bricks made for the purpoſe.

If ſtone taken from quarries is to be uſed, and the drain formed like a conduit at bottom, the trench is made wide enough to contain two ſide ſtones about ſix inches aſunder, and the

ſame in height, with a cap or flat ſtone laid over, which covers and ſecures the cavity through which the water paſſes *. Theſe drains are more expenſive than when the ſtones are thrown in promiſcuouſly, but are the only ones applicable to ſprings, which may be prevented from injuring large tracts of land by cuts comparatively ſhort. But in Eſſex, and the other eaſtern counties, when hollow drains are filled with ſtones, it is uſually with flints from chalk, or with ſtones from gravel pits, or gathered off the fields.

VERY ſmall ſtones do not anſwer well for any but very ſhort drains, in which little water is conveyed, and any ſize require a greater width at bottom than wood or ſtraw, and conſequently renders the expence of cutting greater.

WHETHER the ſtones are large or ſmall, they ſhould be very clean, and free from any clay or earth that may adhere to them, and put in carefully, ſo as not to tumble down any of the earth of the drain, which might be apt to choke up the interſtices betwixt them.

UPON the ſubject of filling drains with wood, Lord Petre thus expreſſes his opinion:

---

* ANOTHER mode of laying the bottom ſtones is deſcribed in Sir H. Fletcher's communication. SECT. XVIII.

"THE drains filled with wood, and covered as uſual with ſtraw or ruſhes, are preferable to ſtones or any other kind of materials; the reaſon is, as the wood decays the water continues to paſs. When filled with ſtones, and the drains ſtop up, which muſt be expected to take place in time, the earth becomes quite ſolid round the ſtones, and as they do not decay, the filtering of the water is for ever obſtructed, not ſo when buſhes or wood are uſed; continual filtering and draining are then for ever to be perceived; and by repeating the operation a ſecond time, cutting the drains tranſverſely of the old ones, the benefit of the filterings through the rotten wood is ſecured, and the ſpewing up of old broken and damaged drains corrected and carried off. Moreover, as buſhes form a much greater number of cavities than either ſtones or poles, they are leſs able to ſtop up, and encourages filtering more than larger and more ſolid bodies."——"A load of buſhes containing one hundred and twenty faggots, will do about three hundred and ſixty rods; and a load of ſtraw containing one hundred and twenty bottles, the ſame; the load of buſhes is generally worth about 14s., and the ſtraw 18s. per load. I therefore calculate this expence about 12s. per acre, ditches a rod apart."

RICHARD PRESTON, Eſq. of Blackmore, a correſpondent of the Board, prefers, on twenty years experience, black thorns to every other material for filling.

THERE is alſo another method of filling with wood, by ſuſpending the faggots or buſhes upon croſs billets ſet on end in the bottom of the drain, as repreſented by No. 5. in the Plate.

THIS kind of drain has been ſucceſsfully practiſed in Berwickſhire, where it is ſaid to have continued running for thirty years.

IT has alſo been attempted at Livingſton, the ſeat of Sir W. Cunninghame, but is not approven of there; for it is ſaid, that the feet of the cattle, in ploughing, went down and deranged the billets that ſupported the brufhwood, and conſequently put a ſtop to the diſcharge of the water; but this has been owing to the want of a ſufficient depth of earth above the wood, which was not more than ſix inches *. This kind of drain is, however, much recommended by the writer of the Agricultural Report of the county of Caermarthen in Wales. He ſays, "The completeſt method I have yet known, is to cut the ſtrongeſt willows, or other aquatic brufhwood, into lengths of about twenty inches, and place them alternately in the drain, with one end againſt one ſide of the bottom, and the other leaning againſt the oppoſite ſide.——Having placed the ſtrong wood in this manner, I fill the ſpace left between them on the upper ſide with the

* SIR W. CUNNINGHAME imported this mode of draining from Richmond Park, near London, where it has been very much practiſed.

ſmall bruſhwood; upon which a few ruſhes or ſtraw being laid, as before mentioned, the work is done. Willow, alder, aſp, or beech boughs, are exceedingly durable, if put into the drain green, or before the ſap is dried; but if they are ſuffered to become dry, and then laid under ground, a rapid decay is the conſequence. I have ſeen willow taken out of a bog after lying there thirty years, and its bark was as freſh and ſappy as if it had been recently cut from the hedge; and it is well known, that beech laid green in the water will continue ſound for any length of time." And

MR. MAJENDIE is of opinion, that wood of eighteen years growth is much more durable than that which is only ten or twelve.

RESPECTING filling drains with ſtraw, the following obſervation by Mr. Vancouver, in his Report of Eſſex Huſbandry, merits attention.

"WHEN the ſoil is a very cloſe and retentive clay, the drains ſhould be made proportionably near to each other, ſhallow, and filled with ſtraw only, it being totally unneceſſary to uſe wood, or any more durable material, upon land where the ſides of the drains are not likely to crumble in. Upon a ſoil like this, the drains ſhould ſeldom exceed the diſtance of three or four yards

apart, and twenty inches deep, or ſuch a depth as may be the moſt conveniently obtained, by firſt opening the drains with the plough, ſhovelling the bottom of the loweſt furrow, and then digging one ſpit only with the land ditch ſpade; and which, materials included, will coſt about 2s. 6d. per ſcore rods.

"DRAINS formed in this manner, through the tough and retentive clays, will be found, in a ſhort time after the work is finiſhed, to have formed over the ſtraw with which the drain was filled, an arch of ſufficient ſtrength to ſupport the incumbent weight of the ſoil, and the caſual traffic of the field. In twelve or eighteen months, it may be obſerved, that the ſtraw, being of one uniform ſubſtance, is all rotted and carried away, leaving a clear pipe through the land in every drain, into which the paſſage of the water may have been much facilitated, by a due attention to the filling of the drains with the moſt friable and porous parts of the ſurface the field might have afforded."

THE lateſt and beſt improvement in filling hollow drains with ſtraw, is that of twiſting the ſtraw into a rope, deſcribed in the following paſſage concerning ſome improvements in Eſſex.

"THE moſt prominent feature of his improvements is a new method of filling land drains: The common practice is to tread in looſe ſtraw; but Mr. Bedwell has invented a method of

winding it into a hard rope, as large as a man's arm, which he forces to the bottom of the drains, and finds from experience, copied ſucceſsfully by his neighbours, to convey the water off more readily, and to have much longer duration; at the ſame time, the quantity of ſtraw conſumed is not increaſed, and the operation of filling accelerated. After the cattle have picked it over, he finds the ſtraw tougher, and in better order to wind, than when quite dry and freſh." The figure in the Plate is a repreſentation (not of Mr. Bedwell's), but of a more ſimple moveable machine, for twiſting the ropes to be uſed in the above manner *.

THE next material to be noticed is bricks made for the purpoſe. Theſe have already been deſcribed in Chapter III., and Plate 12.

THEY are effective, but expenſive, and not ſo well adapted for ſurface draining, except for conducting away ſprings, in which work a ſmall extent of drains may anſwer for a large tract of land. Theſe bricks are made of various ſhapes and ſizes, but generally have a ſemicircular cavity for the water to flow in, and reſt, in ſtiff ſoils, on the ground; in ſoft ſoils, upon each other, forming a circular tube, or on common bricks, as a foundation.

* SEE Foote's Report of Middleſex.

In Eſſex and other counties, pipes of clay, about eighteen inches long, with an opening of three or four inches diameter, are burnt, and applied to ſimilar purpoſes, but are beſt calculated for conveying any ſmall rill of water, or ſpring for the ſupply of a houſe, &c.

The following judicious remarks reſpecting the arch brick, repreſented by No. 3, in Plate 12. have been ſtated by the writer of the Agricultural Survey of Salop: "I have made what I call a brick arch for that purpoſe (of draining), full an inch thick, and a foot long, nearly of the ſhape of a ridge tile, but being not more than five inches wide at bottom, and ſix inches ſemidiameter. It cannot poſſibly be uſed in building; but ſuch having been made at a brick kiln, the exciſe officer thought them taxable, and charged them 2s. 6d. per thouſand, as common bricks. Two members of parliament did me the honour to repreſent this at the proper office in London, in hopes of getting off the tax, which has not yet been done. This has checked the uſe of them; for nothing can be more irkſome than a tax upon a material to be uſed in an eſſential improvement upon land; beſides, there can be no more lawful pretence for taxing the arch brick of that ſhape, than there is for taxing the earthern pans and cups at a pottery. Theſe arches may be made, when common bricks are at 15s. per thouſand, without tax, at about 30s. per thouſand, which will lay a cavity of ſix by five inches, and near 340 yards in length."

SECT. XIII.

Mode of Filling.

THERE is one circumſtance in filling the drains, attended to particularly by farmers, who are moſt ſolicitous to have the work well performed, and that is, to contract with their men only for digging and leaving clean, in order that the filling may be done by men paid by the day, as a greater ſecurity that it ſhould be executed with all poſſible care, and is uſually attended by the farmer himſelf, or ſome confidential ſervant. This is a rational practice, and merits being followed. Mr. Young of Clare obſerves, in the paper quoted before, that, "It is an invariable rule with me, never to ſuffer the man who digs to cover up the drains, but it is left open for me or my bailiff to examine; and then it is well filled up to the ſhoulder with wheat-ſtubble, cut and ſtacked for the purpoſe immediately after the harveſt, and a ſmall ſtick or two at the outlet to prevent its being ſtopped by any external accident. Laſtly, With a common plough, I turn a furrow of the upper ſoil or mould upon the drain, taking care not to turn in any of the dead ſoil raiſed by the land ditch ſpade, which ought always to be laid on the outſide and ſcattered over the land. It is right not to let the drains lie open any length of time, leſt they get injured by wet or froſt; my general rule is, to fill them up every day."

THE different methods of filling both with ſtone, wood, and ſtraw, will be better underſtood by examining the Plate.

SECT. XIV.

Of the Expence.

THE expence of theſe drains, will of courſe vary with the ſoil, depth, price of labour, &c. and theſe circumſtances are ſo different, in different diſtricts, and even in different pariſhes, that it accounts for the various reports of writers on the ſubject. The price in Suffolk to dig and fill two ſpit drains, is 3s. 4d. to 3s. 6d. a ſcore rods, without beer. In the following notes of Eſſex draining, other rates are mentioned, and alſo the coſt of materials uſed in filling, an article liable to equal variations with the labour.

MR. JAMES YOUNG ſays,—" It is not eaſy to aſcertain the price of carting the wheat-ſtubble to the place where it will be wanted, and ſtacking it, becauſe the value muſt depend upon the diſtance: it is equally difficult to ſay what the work of the ploughs ought to be valued at; for, though ſeveral acres may be drawn out in a day with one plough, yet I never chooſe to do above two or three hours work at a time; therefore I ſhall leave every farmer to fix his own price upon theſe parts of the buſi-

neſs, only deſiring him to conſider, that it is work that will wait for a leiſure time, and frequently, if the horſes were not ſo employed they would earn nothing.

"I PAY for digging the land drains 1s. 8d., and for filling them up with ſtubble 4d. per ſcore rods, without any beer whatever. An active man, uſed to the work, where the ſoil is not ſtony, will dig twenty-three or twenty-four rods in a day, within working hours.

"THE ſtate of the expence, that is, the money a farmer will pay out of his pocket for land-draining an acre of land, will ſtand thus:

For cutting and raking together an acre of wheat ſtubble, generally ſufficient for an acre of drains, -	L. 0	2	0
Digging eight ſcore rods of drains, - -	0	13	4
Filling them up with ſtubble, - - -	0	2	8
Extra work with the common ſpade, on an average, a day's work for a man, - - -	0	1	4
	L. 0	19	4."

LORD PETRE ſays,—"The value of the work of the plough varies according to different people's method. My general method is, to plough with a common plough and a pair of horſes,

two furrows different ways, leaving a baulk in the middle, which I afterwards plough out with a larger plough, and three horſes abreaſt, which will turn a furrow regularly about two inches deeper than the land is generally ploughed. The expence, not reckoning any thing for the maſter, who, I ſuppoſe, attends and marks out the ditches, is about 18d. per acre, ditches a rod a part. This method is for fallow. The labour of digging is 2¼d. or 2½ per rod.; and the expence, per acre, of the whole work, is, as near as I can gueſs, on a fallow where two ſpits are digged, 43s. 6d. per acre; with the plough and one ſpit, about 35s.; on lay, with the plough, about 35s.; without the plough, and the ſpits ſet, about 47s. per acre."

Mr. Majendie informs the Board, that the expence to him is,

Digging the drains with the ſmall or laſt ſpit ſpade, per ſcore yards, - - - -	20d. to 24d.
Two ſpits in main drains, - -	3s. to 3s. 6d.

In this manner the under draining one acre (the drains at one rod apart), including wood, ſtraw, and all other incidental charges, amounts to an expence of from 40s. to 45s. an acre.

SECT. XV.

Of Sod or Pipe Drains.

VARIOUS methods have been deviſed of ſaving the expence of materials in the filling of drains. The ſod or pipe drains are undoubtedly the leaſt expenſive of any, and may be of conſiderable benefit on ſome ſoils; but their duration, and ſafety in ſupporting heavy cattle or horſes in the act of ploughing, cannot be very much depended on, unleſs when the opening is at a conſiderable depth from the ſurface, and when the upper mould becomes incruſted, or forms an arch.

THE method of executing them is, by digging a trench of a certain width ſo deep; and then, by taking out the laſt ſpit with the narrow draining ſpade, a ſhoulder is left on each ſide, upon which a ſod or turf, dug in graſs land, is laid, graſs ſide downwards, and the mould thrown in over it. It is ſaid that ſuch drains will continue hollow, and conſequently diſcharge well for a great number of years. The mode of executing them has been well deſcribed, and the tools repreſented, by T. B. Bayley, Eſq. in the valuable Georgical Eſſays publiſhed by Dr. Hunter of York*.

* Octavo Edition, p. 437.

Sod or turf drains are pretty much in uſe in ſome of the northern counties of England, where land ſtones are ſcarce.

Several moſſes have been drained in Lancaſhire nearly in the ſame manner, by leaving ſhoulders about a foot and a half from the bottom, and laying over theſe croſs pieces of turf or peat, cut into lengths of ſixteen inches, and eight or nine inches ſquare, which, after they have been dried by expoſure to the ſun and air, eaſily ſupport the looſe mould that is thrown in above them, the thickneſs of which being for the moſt part from two to three feet.

How long theſe drains, in ſuch ſoft ſoils, may laſt good, cannot be aſcertained, as it is not long ſince the practice was firſt introduced.

Another ſimple mode of making pipe drains has been ſucceſsfully attempted; but it is better calculated for the purpoſe of an aqueduct or conveyance for the water than for drying the ſoil.

A drain is dug to the neceſſary depth, narrow at bottom, in which is laid a ſmooth tree or cylindrical piece of wood, ten or twelve feet long, ſix inches diameter at the one end, and five at the other, having a ring faſtened in the thickeſt end. After ſtrewing a little ſand upon the upper ſide of the tree, the clay or tougheſt part of the contents of the trench are firſt thrown

in upon it, and then the remainder, which is trod firmly down. By means of the ring and a rope through it, the tree is drawn out to within a foot or two of the ſmall or hinder end, and the ſame operation repeated. A gentleman who has tried this experiment ſays, " This clay pipe has conducted a ſmall rill of water a conſiderable way under ground for more than twenty years, without any ſign of failing."

On ſheep paſtures, a very ſimple mode of carrying off ſurface water, by means of a ſtrong common plough, may be effected in this manner: after turning up furrows through the hollow parts of the field where the water is apt to ſtagnate, let a man with a ſpade pare off the looſe ſoil, leaving the inverted ſod or graſſy ſide about three inches thick; this done, let him turn over the ſod into the furrow, graſs ſide up. By this, a canal or opening of three or four inches will be left in the bottom of the furrow, ſufficient to diſcharge a conſiderable quantity of water, which will readily ſubſide into it.

A great extent of ground may ſoon be gone over in this way, and when the furrows choke or grow up, the ſame operation can be repeated at very little expence. This is peculiarly adapted for ſheep paſtures injured by ſurface water.

SECT. XVI.

Duration.

THE duration of hollow drains will neceſſarily depend on the nature of the materials with which they are filled, and in ſome meaſure on the quality of the ſoil; as certain ſpecies of land have the power of preſerving wood or other periſhable materials much longer than others.

STONES laſt till accidental cauſes impede the flowing of the water, and may laſt for ever. Wood, periſhes in certain periods; but it does not follow that the drains ſhould ſtop. If the earth arches, the water will neceſſarily continue to flow, which is found to be the caſe when wood, ſtraw, and ſtubble are rotten and gone. Drains that have been filled with buſhes and ſtraw (both which were rotten), have been obſerved to run well forty years after making.

ON this ſubject, Mr. Young of Clare obſerves, "I have never been able to aſcertain the duration of the ſtubble with any degree of exactneſs, neither have I ever drained a field a ſecond time, but a drain will ſometimes be ſtopped by carting on the land in the wet, or ſome other accidental cauſe; in which caſe, as ſoon as it is diſcovered by the wetneſs of the place, my prac-

tice is, to make one or more freſh drains in different directions to the old ones, and I have many times obſerved old drains, when cut acroſs, though there was not the leaſt appearance of any vegetable ſubſtance remaining in them, but full of looſe porous earth, at once run freely, or, according to my workmen's phraſe, *BLEED FRESH*."

"During the wet weather, about the middle of laſt April, I examined a field of ſix acres, which I land-drained in the month of November in the year 1773, and had the ſatisfaction to find every drain in the field (except one) running."

SECT. XVII.

Drainage of Stiff and Retentive Soils by means of Open Cuts, and the proper Formation of Ridge and Furrow.

It has already been hinted in Section IV. that, on ſome ſoils where the ſurface is very retentive, no number of covered drains can operate effectually in drying the ground.

In moſt of the central counties of England, and alſo in Flanders, the general mode of drying land is, by ploughing it up in high and broad ridges, from twenty to thirty, and even forty feet wide, with the centre or crown three or four feet higher than

the furrows. The ſucceſsful practice of the Flemings ſhows clearly how effective this method is when well executed; for, by attentively keeping the furrows perfectly free from water, the land is kept in ſo dry a ſtate, that all ſorts of crops flouriſh remarkably well: But in England, the ſame obſervation would not be juſt, for want of the ſame attention to this mode of practice. In many inſtances, the furrows are not properly directed nor properly deepened, and the ridges too flat, by which the water ſtagnates in the hollows, and of courſe renders that part of the field worſe than loſt. This bad management has brought the method itſelf into ſuch diſcredit, that, in many places, they have been levelling their ridges at conſiderable expence, in order to adopt ſome other method of draining; an operation which, on clay ſoils, is certainly very imprudent; for when the ridges are well rounded, not too high, and the furrows kept open and perfectly free from retaining water, it muſt be eſteemed, for land of a very retentive ſurface, an excellent mode of draining, or for keeping it dry.

Much has been written againſt high ridges, but not with due conſideration of their propriety in ſuch lands; they have been applied on dry loams moſt abſurdly; and from being perhaps a cuſtom in that part of the country, no diſcrimination has been made: But their being improper in ſome caſes, and ill managed in others, affords no juſt argument againſt them, when well adapted to the ſoil and wetneſs of climate.

THEY prove of great utility, even although united with either open ſurface cuts or hollow drains, as will appear from the following information that has been tranſmitted to the Board of Agriculture, on this ſubject.

MR. FRANCIS GOUDE, of Coſſington in Leiceſterſhire, has united in this manner the ridge method, and hollow drains in the furrows, and with a ſucceſs that renders his account intereſting.

HE obſerves, "That his ſoil is ſandy on the ſurface, from ſix to ten inches deep; red clay at the bottom, and in ſome places gravel, which throws the water upon the ſurface of the land; which ſoil we find not eaſily drained by croſs cuts, but requires hollow drains to be made in the furrows of the ridges, which are made from five to ten yards broad. Their height varies; for ſummer corn we raiſe them ſix inches, but for winter crops twelve at the crown, above the bottom of the furrows. The hollow drains are thus dug: In turf ground, make the drain fifteen inches wide, and two feet deep, going down ſloping. Firſt take a ſpade and cut the turf out, then make uſe of another tool, made on purpoſe, ſomething like a cheeſe-taſter; at the head, where the man ſets his foot, is ſeven inches wide, going narrower downwards to the length of ſixteen inches, with which he digs out the other materials, whether it be ſand, gravel, or clay. If clay, they cut four inches deeper in the middle, at the bottom of the drain, and four inches wide, leaving two

inches on each ſide, or what they call ſhoulders, to ſupport the turf, which is laid flat upon it, with the graſs downwards; then fill it up again. If the land is of a mixed ſoil, ſuch as ſand, gravel, &c., it muſt be made with thorns or elm boughs, trampled down, and the turf laid upon them as before, cloſe to the ſides of the drain, ſo that it makes as it were a wall; but where ſlab, ſlate, or ſtone can be had, it is ſtill firmer. The bottom of the drain is about four inches wide, and workmen have a tool made the ſame way as a hoe, or in form of the letter L, with a half-round at the bottom, to ſcoop out the ſmall particles of earth that will remain at the bottom of the drain. How long they will laſt good is unknown; but I can anſwer for fifteen years, and expect them to endure a much longer time even filled with buſhes: and the improvement may, upon an average, be eſtimated at one fourth increaſe in the crops."

The mode of ridging and croſs thoroughing (furrowing) land in the Carſe of Gowrie, Perthſhire, is particularly deſcribed in the following valuable communication, by George Paterſon, Eſq. of Caſtle Huntly in that county.

As clay is perfectly impervious to water, ſurface draining is the only means by which this ſpecies of improvement can be accompliſhed; and all over the Carſe of Gowrie this operation is extremely ſimple. There are certain large common drains, which paſs through the diſtrict in different directions, ſufficient-

ly capacious to receive the water drained from the fields by the ditches which furround them, and of ſuch a level as to carry it clear off, and to empty their contents into the river Tay. There are alſo ditches which furround every farm, or paſs through them, as their ſituation may require, but in ſuch manner as to communicate with every field upon the farm. Theſe ditches are made from two to four feet wide at top, and from one and a half to one foot at the bottom, a ſhape which prevents their ſides from falling in; but even then they muſt be cleanſed and ſcoured every year, at a conſiderable expence. If the fields be of an uniform level ſurface, the common furrows between the ridges, provided they be ſufficiently deepened at their extremities, will ſerve to lay the grounds dry; but as it ſeldom happens that any field is ſo completely free of inequalities, the laſt operation, after it is ſown and harrowed in, is to draw a furrow with the plough through every hollow in the field, which lie in ſuch a direction that it can be guided through them ſo as to make a free communication with any of the ditches which furround the farm, or with any of the furrows between the ridges, which may ſerve as a conductor to carry the water off to the ſurrounding ditches. When this tract is once opened with the plough, it is widened, cleared out, and ſo ſhaped with the ſpade, that it may run no riſk of filling up. Its width from 6 inches to a foot, according to its depth, which muſt depend upon the level of the field; but the breadth of a ſpade at bottom is a good general rule. It frequently happens that there are inequalities in ſeveral parts of the

ſame field, which do not extend acroſs it, or which do not paſs through it in any direction that a plough can follow; but which may extend over two ridges, or one ridge, or even part of a ridge. Such require an open communication to be made with any furrow which may ſerve as a conductor to carry off the water, which are always made with the ſpade. All theſe open communications are here called *GAAS*, and to keep them perfectly clear, is a very eſſential part of every Carſe farmer's attention.

It is as yet a general practice in the Carſe to have head ridges, as they are called, at the two extremities of each field, *i. e.* the riſing ground upon which the plough turns is laid up in the ſhape of a tranſverſe ridge, higher in the middle and falling off at each ſide; ſo that a *GAA* is made in the courſe of the inner furrow, with which the whole furrows between the longitudinal ridges communicate, and into which they pour all their ſurface water, which is carried off by ſimilar *GAAS*, or openings, cut through the head ridges at convenient diſtances, and by which the whole is emptied into the adjoining ditches, and by them into the main drain.

It is ſuppoſed, that it would be a much better plan, inſtead of forming head ridges as above deſcribed, to lay the earth up to the ends of the longitudinal ridges, uniformly, which could eaſily be done, with a little more trouble, by returning with

an empty plough. There would then be no depreſſion between the longitudinal and tranſverſe ridges; of courſe no occaſion for a *GAA*; and by cutting fairly through the head ridges oppoſite to every longitudinal furrow, a freer paſſage would be given to the ſurface water from the whole field to the adjoining ditch, and of courſe the draining be more complete *.

Besides all this, an experienced Carſe farmer will take care that his grounds are carefully ploughed; that the land is laid up equally, that no inequalities are left ſo as to hold water: That the ridges are properly rounded, neither too high nor too low, but as near as poſſible to the ſection of a large circle; by which the ſurface water will eaſily drain off without lodging; and while the crowns are not too much enriched, nor the furrows impoveriſhed, the whole will be made equally fertile, dry and prolific, and not unfrequently be acceſſible to the plough earlier in the ſpring than the fields upon the declivities of the ſurrounding hills.

* This method Mr. Paterſon has followed upon all the fields which he has levelled.

SECT. XVIII.

Drainage of Clay Soils injured by Surface Water.

THE following method of draining clay ſoils, wet from rain or ſurface water, has been practiſed by Sir Henry Fletcher, Bart. a member of the Board of Agriculture, with great ſucceſs:

THE upper ſoil, or that above the clay, was from four to ten inches deep, and of good quality; but being in a mountainous part of the country, and near the ſea, a great quantity of rain fell, which always kept the upper ſoil full of water, and produced a very coarſe graſs, not worth more than 3s. an acre. The ſubſtratum of clay was of very great depth. The mode he firſt purſued, and which proved too expenſive, was the common one of the country; the drains twenty inches to two feet wide and deep, ſquare, and filled up promiſcuouſly with quarried ſtones to within nine inches of the ſurface. The quantity of ſtones thus requiſite was ſo great, that the quarrying and diſtant cartage came abundantly too high; ſo that the total expence did not amount to leſs than 3½d. or 4d. per yard, and by the acre to 10l. To leſſen ſo heavy an expence, he changed the method to that which he has followed for many years, viz. On graſs land he digs twenty-two inches deep; the firſt ſpit is of the turf, which is dug carefully out, and preſerved unbroken,

graſs ſide up, along one ſide of the cut; then, with a very ſtrong ſpade, eighteen inches long, ſix inches wide at top, and two at the bottom, he digs a ſpit in the clay, which the men ſpread about the land on the ſide of the drain oppoſite to where the turfs were laid, as far as poſſible from the drain, ſo as none may get in again. A ſcoop to clear out the fragments in the bottom follows, which are alſo ſpread in like manner. They are then ready for filling; and in doing this, he takes three ſtones of a thin flat form, two of which are placed againſt the ſides of the drain, meeting at bottom; and the third caps the other two, as repreſented by No. 3. in the Plate of Sections. Thus a hollow triangular ſpace is left to convey the water, which is ſubject to no accidents that can fill it up, or impede the current. Stones always ſink deeper in the ground; and, in the common method, this frequently cauſes ſtoppages by their being partly buried in the clay; but the triangle, when it ſubſides, does it regularly, and keeps its form and paſſage for the water clear. One cart load of ſtones, in this way, will do a conſiderable length of drain. They are carefully laid down by the ſide of the cut with a ſhovel or baſket; and if there are any ſmall refuſe ſtones left on the ground after the drain is ſet, they are thrown in above. The ſtones being thus fixed, the ſods are laid on them with the graſs ſide downwards, and none of the clay uſed in filling up.

THE expence is a halfpenny per yard, the men earning 2s. and 2s. 6d. per day.

IT is always neceſſary to ſurvey them twice; firſt, when the drains are opened, to ſee if they are of the proper depth; ſecond, when the ſtones are ſet before the ſod is laid in.

IN regard to the diſtance neceſſary from drain to drain, Sir Henry tried them at ten yards; but the ſpaces in the middle between them were not ſufficiently drained. At five yards aſunder they were perfectly effective in the moſt retentive ſoil; at ſix anſwered well; but he found that they would not operate a cure any where, if more than ſeven yards aſunder. Drains made in this manner, give, after many years, no ſign of failing, and will probably laſt for a very long period.

THE Engliſh acre being four thouſand eight hundred and forty ſquare yards, the neareſt ſquare of that is ſeventy yards; and a ſquare of ſeventy yards, drained at ſeven yards diſtant, is ten drains of ſeventy yards each; conſequently there is ſeven hundred yards of drain in an acre, or one hundred roods of ſeven yards each, which, at a halfpenny a yard, is 1l. 9s. 2d. per acre.

WHEN this is the price, the ſtones are half a mile diſtant; if further off, allowance muſt be made for the extra cartage; or

when the ground turns out ſtony, hard and ill to dig, a farther allowance is likewiſe made.

SECT. XIX.

Of the Benefit derived from Draining in general.

In the introduction, I have mentioned ſome of the advantages that ariſe from a proper drainage of land, and alſo, what further benefit may be derived, from the principles of Mr. Elkington's ſyſtem being applied to other uſeful purpoſes. Here, I ſhall only add a few obſervations communicated to the Board on this ſubject.

Of all the improvements by which intelligent huſbandry has advanced the value of land, to the equal benefit of the owner, occupier, and to the public, there is not perhaps another from which ſo many advantages have been derived, at ſo moderate an expence.

Soils that are wet from ſpring or from rain water, are equally unproductive, till laid dry. Seaſons of tillage are loſt, if the land is in an arable ſtate *, and in very wet years, its produce is

* That the ancient Romans were ſenſible of this, and that wet land was fit neither for being ploughed, harrowed, nor planted, Columella obſerves, " Ne lutoſus

ſcanty and precarious; but when *WELL DRAINED*, all other exertions of good huſbandry are attended with beneficial conſequences, and take full effect. The farmer thrives on the ſame farm on which his predeceſſor was ruined! Of its effects on graſs land, Lord Petre obſerves, that, "The land, after draining, not being ſo much chilled by the long continuance of the winter water on the ſurface, produces earlier vegetation in the ſpring; the graſs is rendered of a better kind; the white clover is encouraged, which ſeldom fails in Eſſex and in Hertfordſhire to chequer the *LAND-DITCHED* fields with its ſweet appearance." And again,—"Tillage land is much more manageable, it dries gradually and early in the ſpring; the bad effects of land being catched full of water, when the parching winds in March ſuddenly harden the ſurface of wet grounds, is prevented, and the earth breaks kindly. This in a ſhort time alters the very nature of the ſoil; the weeds and graſſes change their colour; every plant that grows loſes the appearance of rankneſs; the corn increaſes in quantity and weight; and every benefit a farmer can wiſh, is more or leſs the conſequence of this firſt of all improvements, in proportion as the ſoil draws well or ill."

RESPECTING the further advantages of the practice on arable

---

ager tractetur,——Nam quæ limoſa verſantur arva toto anno deſinunt poſſe tractari, nec ſunt habilia ſementi, aut occaſioni, aut ſtationi.

Col. Lib. II. cap. iv.

land, he likewiſe obſerves, "The great advantage of land draining, is, we can plough earlier in the ſpring, and later in the autumn; and it certainly makes the land tilth eaſier, and the land can be kept clean with leſs expence; but it is too much for the farmer to expect his return the firſt crop. I believe I have known ſome particular piece that has repaid the expence in two crops. It certainly is a very beneficial improvement to the farmer."

Mr. YOUNG of Clare ſays, "I have a field that uſed to be ſo wet and poachy in the winter, as not to be able to bear the weight of a ſheep; I land-drained and fallowed it; then ſowed it with wheat, without any manure, and had a crop equal to half the value of the land."

IN ſpeaking of the improvements in the county of Eſſex, Mr. Vancouver has the following remark on the importance of draining. "There is no improvement to which the heavy land huſbandry of this county owes ſo much, as to the fortunate introduction and continuance of the practice of hollow draining. The means of melioration, and the conſequent ſources of fertility thence derived from the ſoil, over and above what it formerly yielded, are not more important and valuable in the preſent day, than permanent and precious, as they muſt prove in their conſequences hereafter. The few inſtances of invincible

blindneſs to the beneficial effects of this excellent practice, go no farther than to prove, that where the work is not properly executed, it never ceaſes to fail in producing the deſired effect."

CONCLUSION.

I HAVE thus endeavoured to explain, in as preciſe and explicit a manner as the nature of the ſubject would permit, the various circumſtances and data, on which the Art of Draining Land is founded; together with the manner of its application in different caſes, and ſuch directions as I hope will enable the practical farmer to profit by the diſcovery.

It will afford me the moſt laſting ſatisfaction, if this Account is found materially to contribute, in extending the knowledge and practice of an art, of ſuch general importance, and ſo likely to promote the intereſt of the farmer, and of the public in general.

EDINBURGH,
Sept. 15, 1797. } JOHN JOHNSTONE.

CONCLUSION